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(54) **METHODS AND SYSTEMS FOR USING
EXTERNAL DISPLAY DEVICES WITH A
MOBILE COMPUTING DEVICE**

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(58) **Field of Classification Search**

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G06F 1/1643; *G06F 3/0486*; *G06F 3/1415*;
G06F 3/0481; *G06F 2203/04803*; *G09G 5/006*; *G09G 5/363*; *G09G 5/12*; *G09G 2340/145*; *G09G 2360/06*; *G09G 2370/16*;
H04M 1/72527; *H04M 1/7253*; *H04M 2250/16*

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USPC 709/203, 226
See application file for complete search history.

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G06F 3/0486 (2013.01)
G06F 3/0488 (2013.01)
G06F 3/14 (2006.01)
G06F 9/44 (2006.01)
G09G 5/00 (2006.01)
G09G 5/36 (2006.01)
G09G 5/12 (2006.01)

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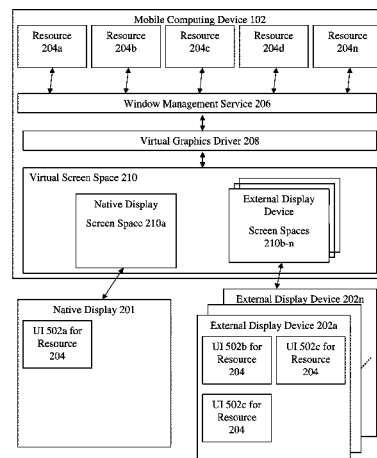
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CPC **H04M 1/7253** (2013.01); **G06F 1/1643** (2013.01); **G06F 3/0481** (2013.01); **G06F 3/0486** (2013.01); **G06F 3/04886** (2013.01); **G06F 3/1415** (2013.01); **G06F 3/1454** (2013.01); **G06F 9/4445** (2013.01); **G09G 5/006** (2013.01); **G09G 5/363** (2013.01); **H04M 1/72527** (2013.01); **G06F 2203/04803**

ABSTRACT

The present disclosure relates to methods and systems for using external display devices with a mobile computing device. The mobile computing device may be repurposed to display a virtual input device for interacting with a resource with output data being displayed on an external display device.

20 Claims, 38 Drawing Sheets



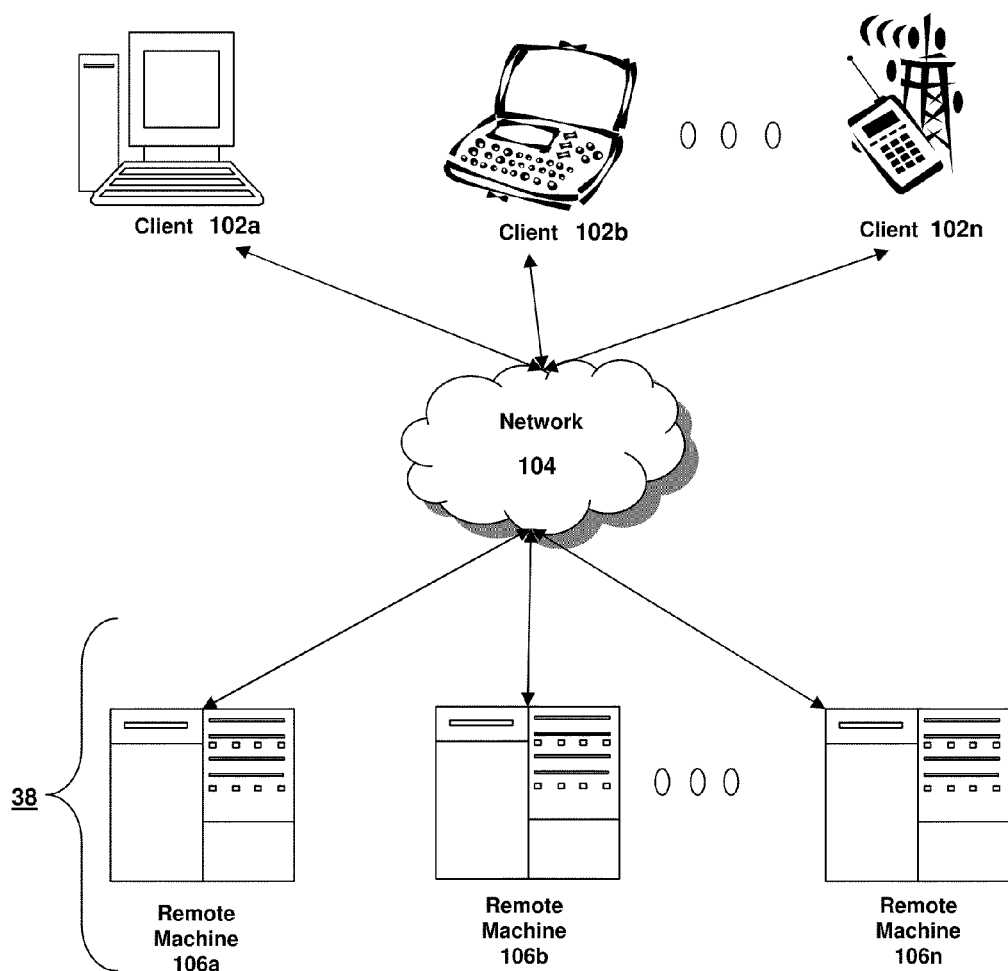
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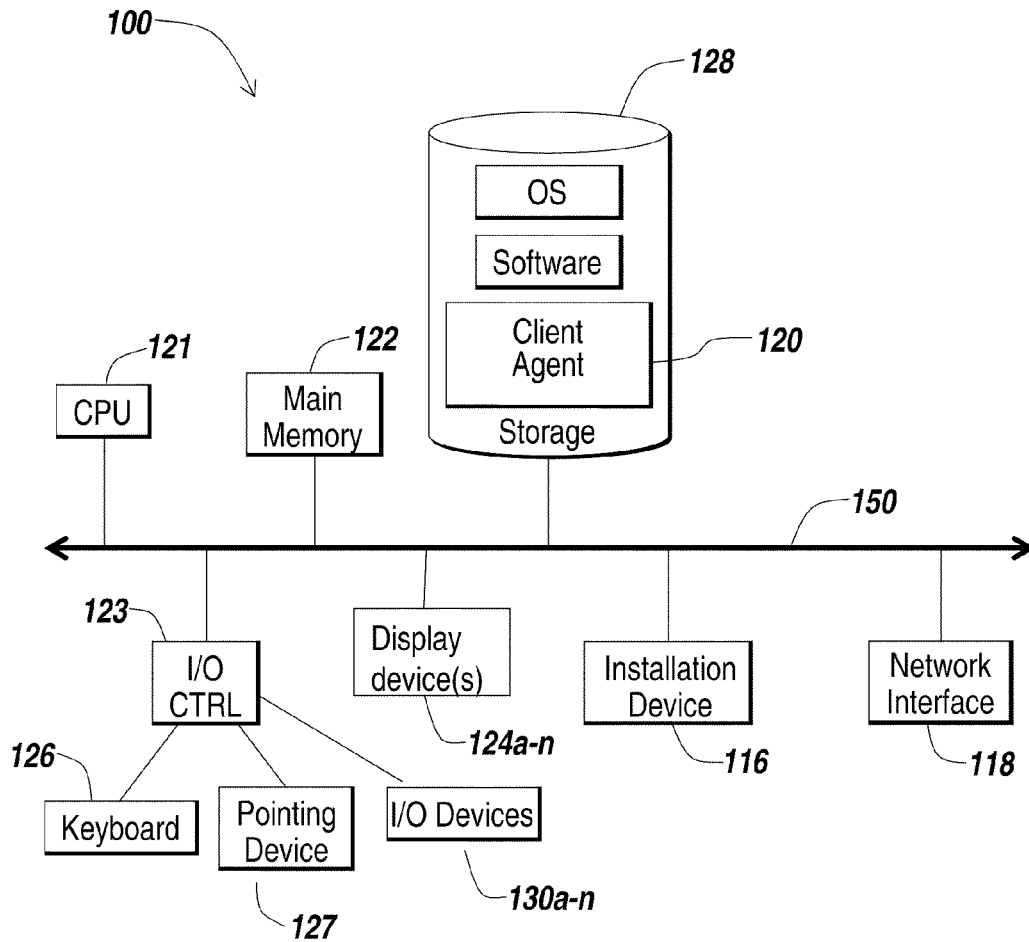
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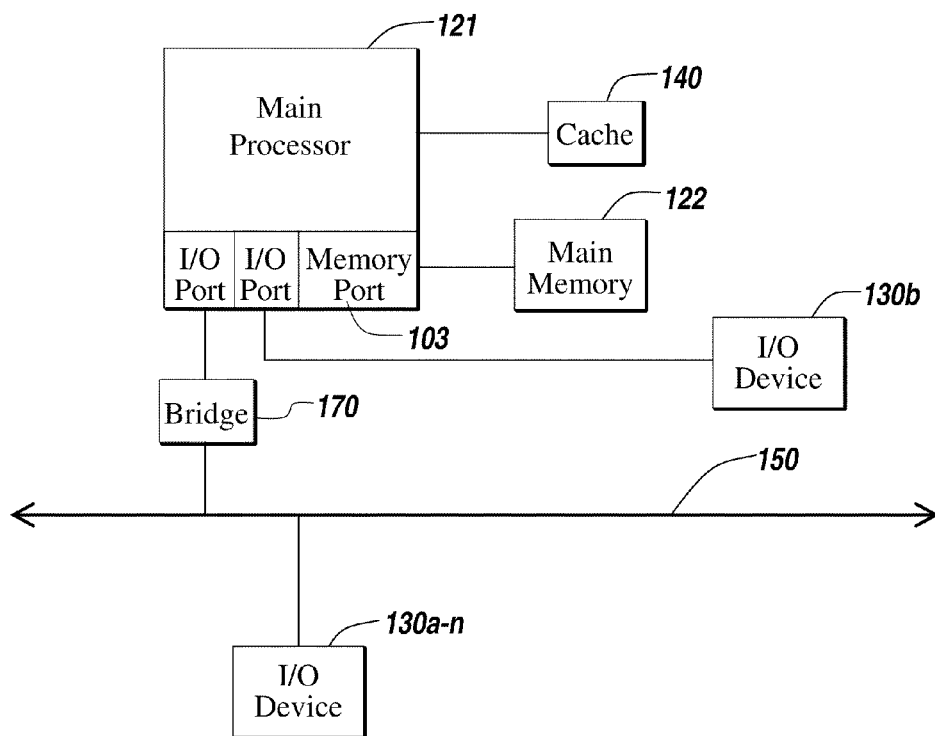
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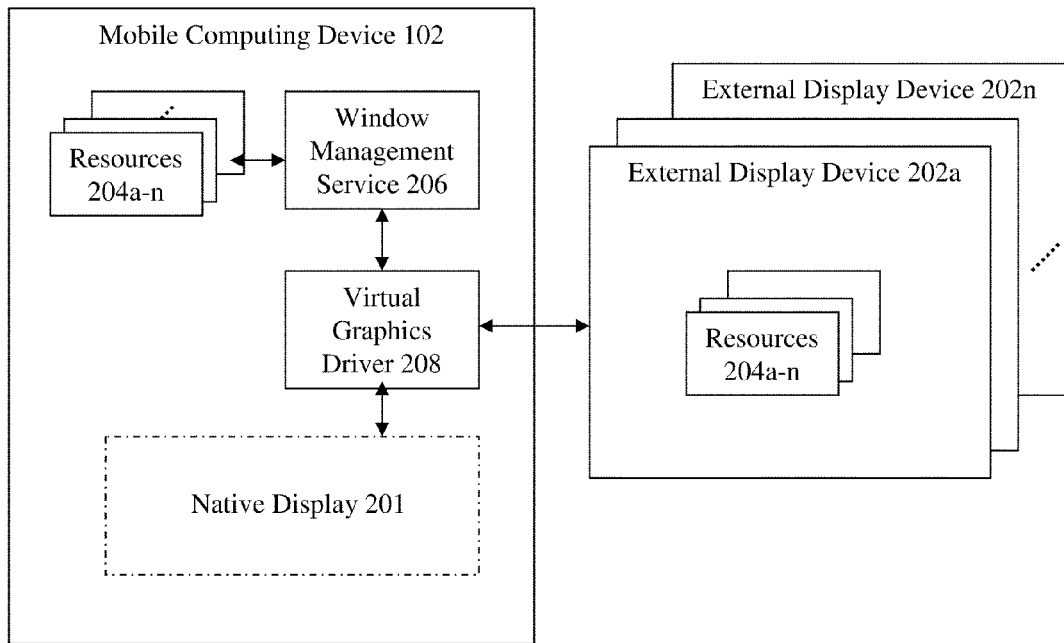
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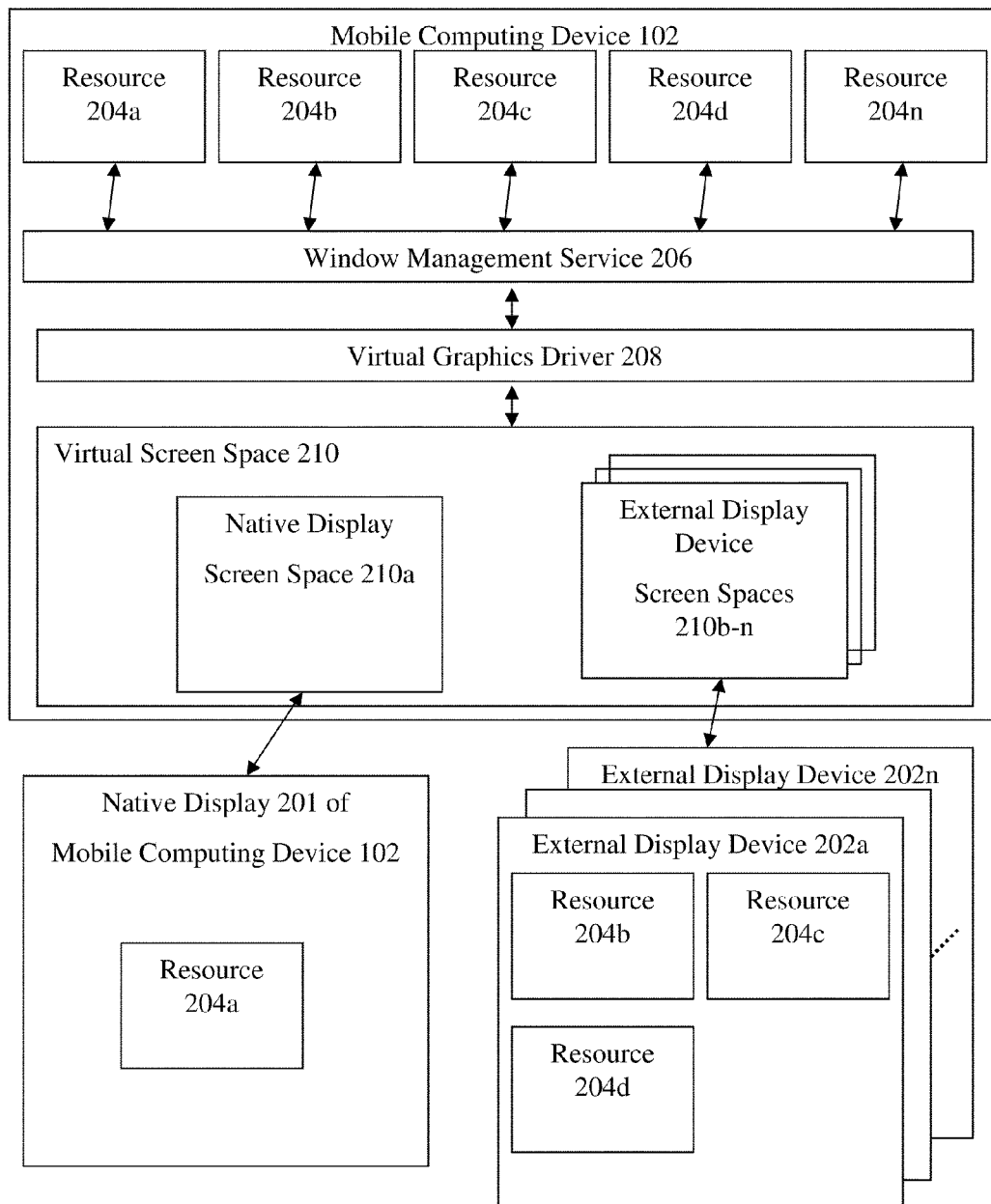
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*Fig. 1A*

*Fig. 1B*

*Fig. 1C*

*Fig. 2A*

*Fig. 2B*

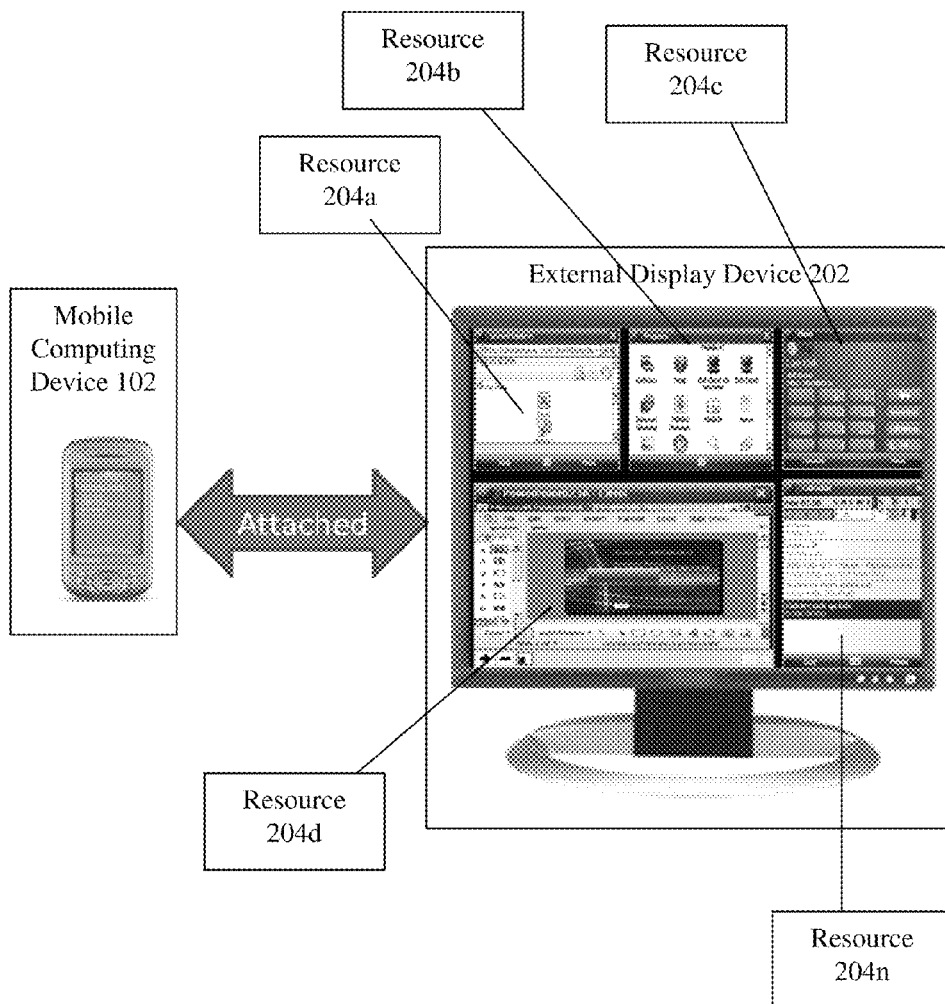
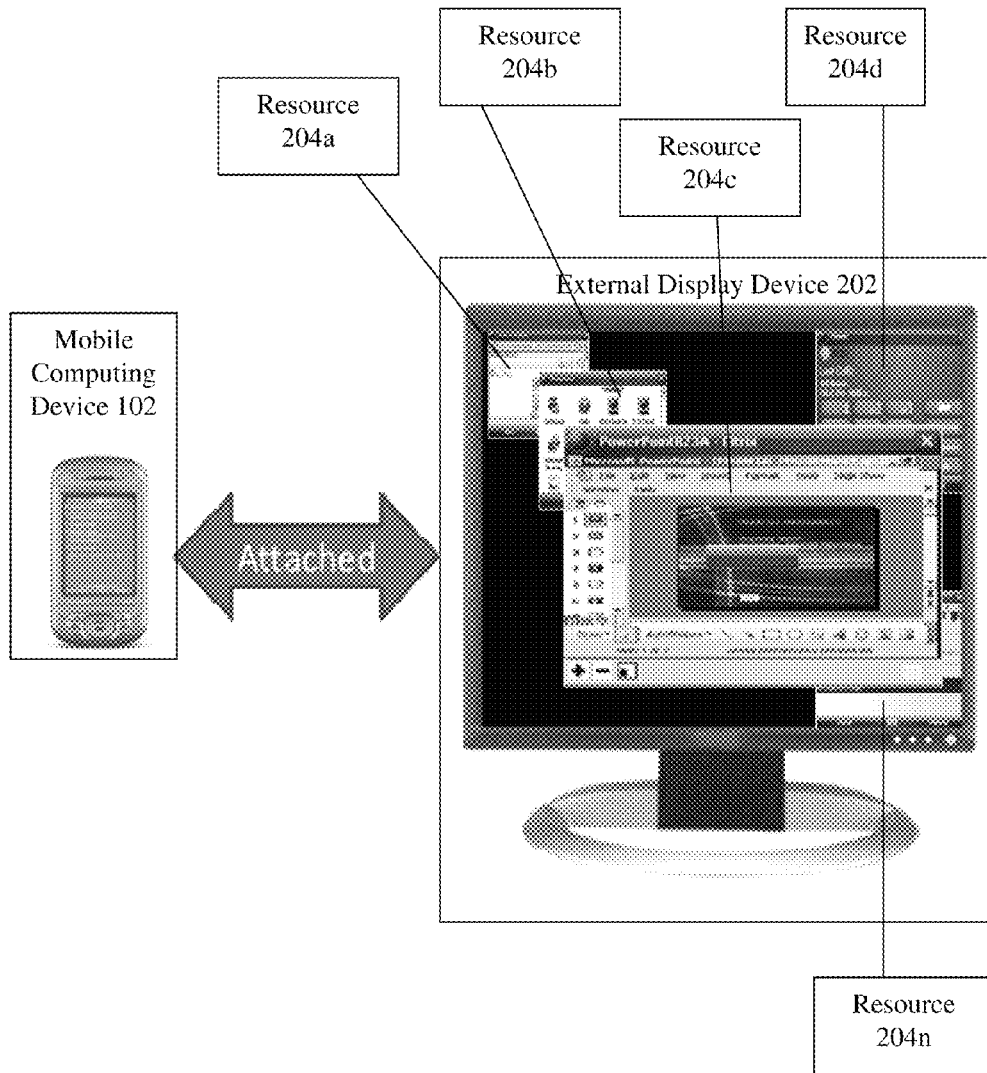
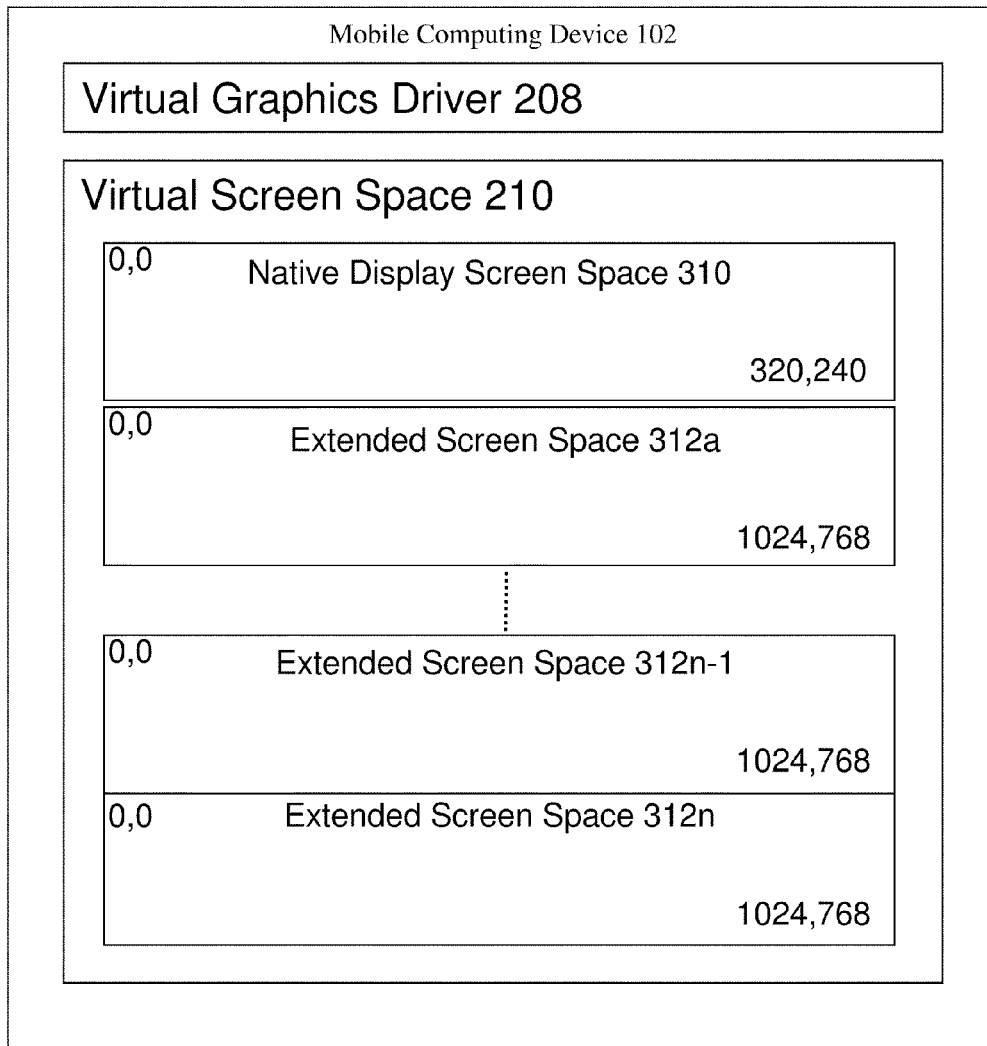
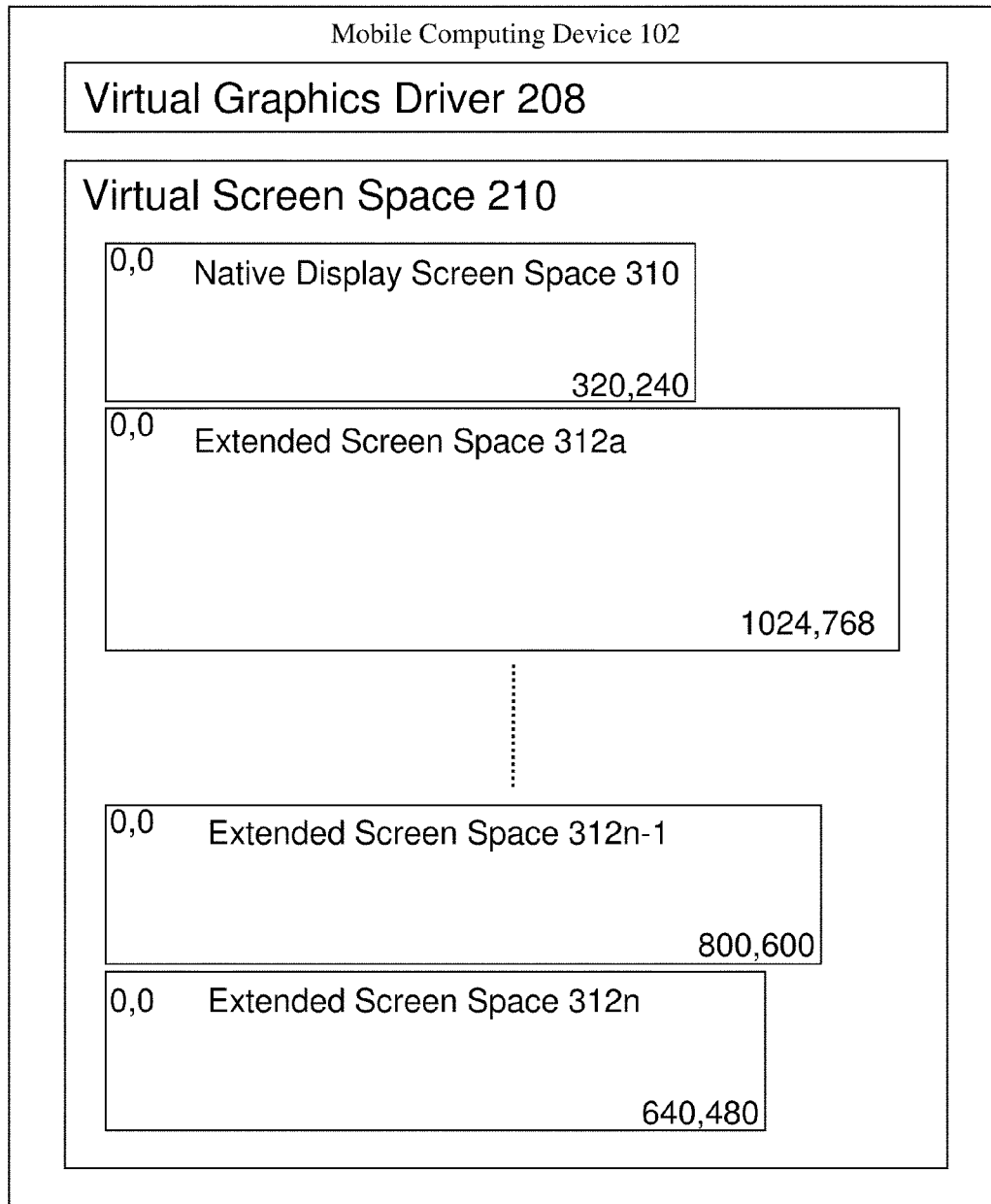
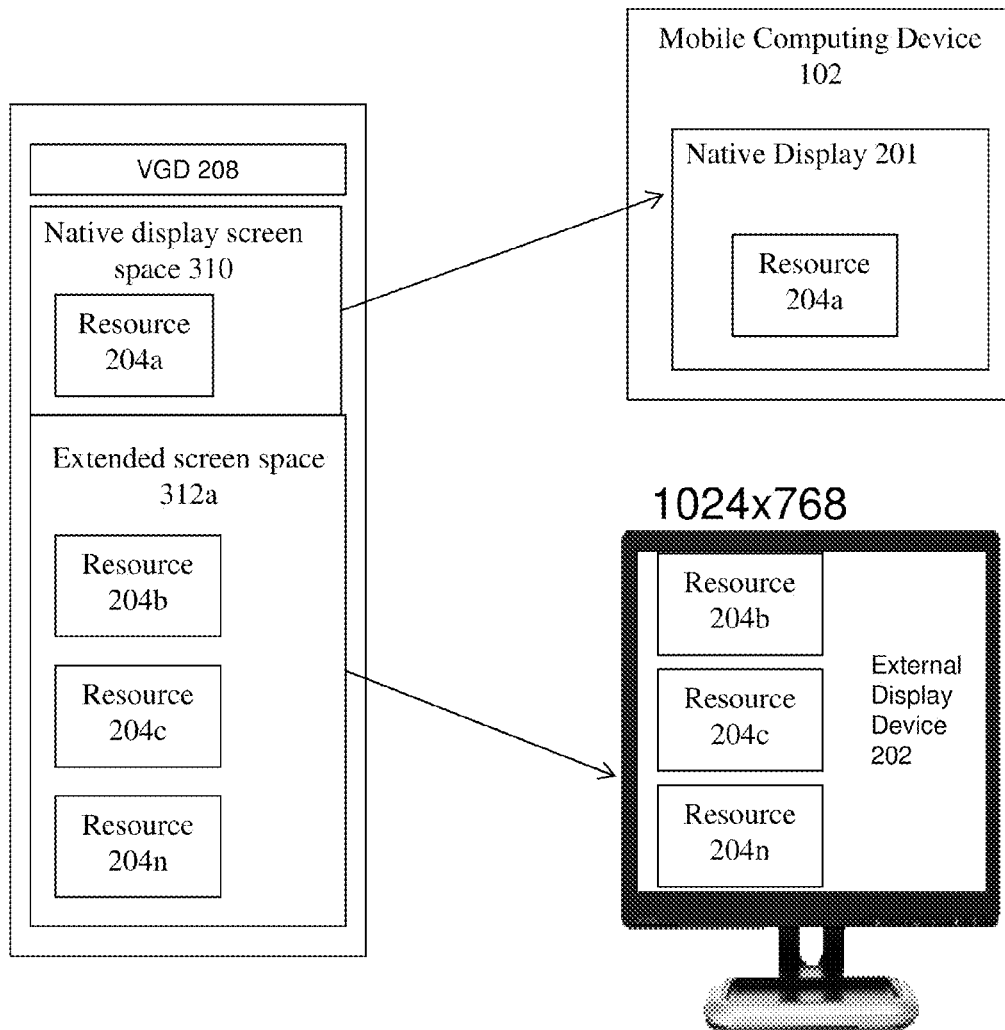


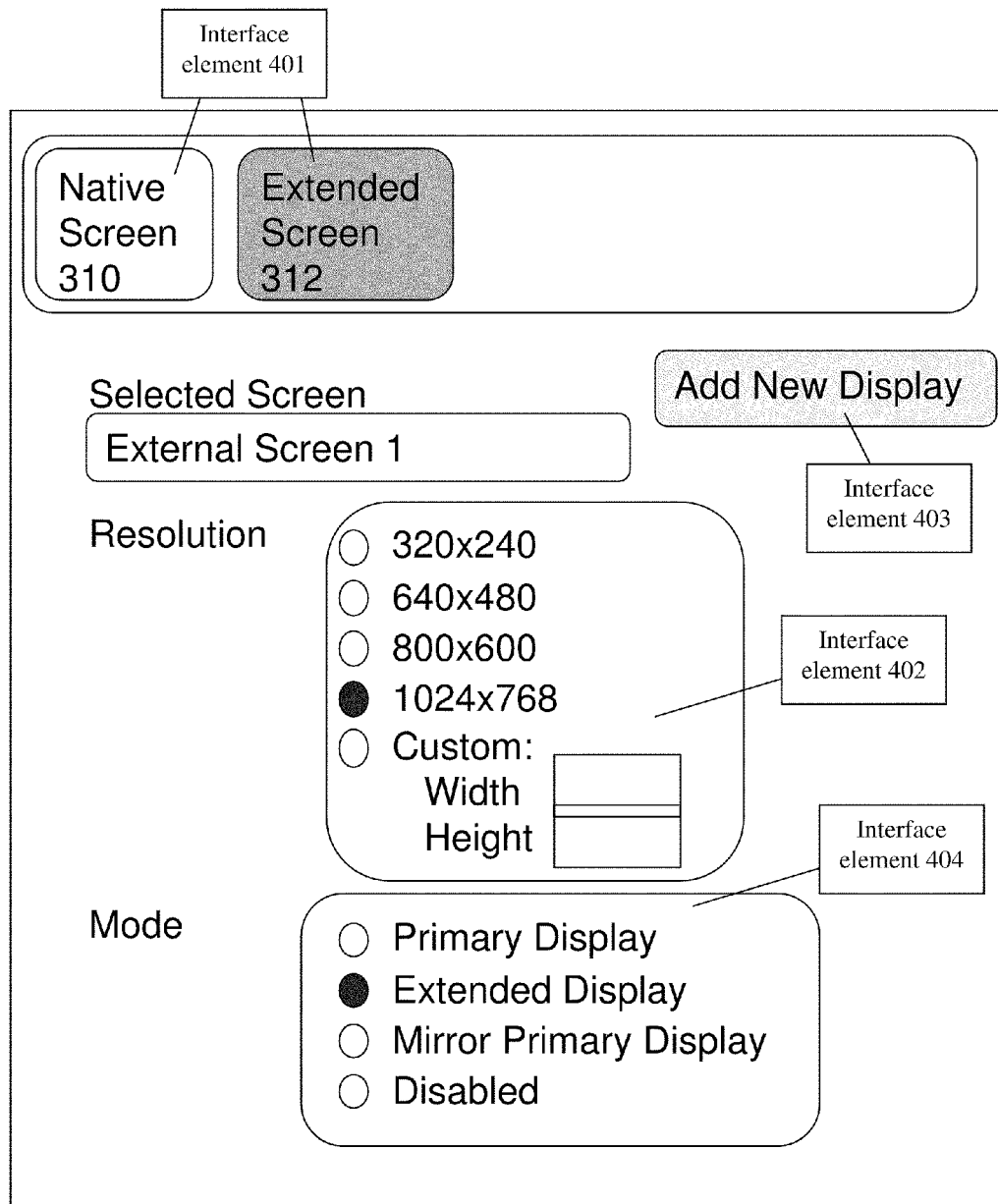
Fig. 2C

*Fig. 2D*

*Fig. 3A*

*Fig. 3B*

*Fig. 3C*

*Fig. 4A*

The interface is divided into several sections. At the top, there are two buttons: 'Native Screen 310' and 'External Screen 312'. Below these, a 'Selected Screen' label points to a text box containing 'External Screen 1'. To the left of this is a label 'Interface element 408'. Below the 'Selected Screen' section is a 'Select a Grid Cell Resolution' label. To its right is a group of radio buttons for resolution: '320x240', '800x600', 'Auto-Fit', '640x480', and '1024x768'. Below these is a 'Custom' option with input fields for 'Width' and 'Height'. The bottom section contains an 'Add Cell' button and a 'Delete Cell' button. The 'Add Cell' button has a callout box with instructions: 'Click Add Cell and then drag the cell into the position you want, then click the cell to lock into position'. The 'Delete Cell' button has a callout box with instructions: 'Select the cell you want to delete on the right, and select the Delete Cell button above.' To the right of these buttons is a grid with four cells: 'Cell 1', 'Cell 2', 'Cell 3', and 'Cell 4'. 'Cell 4' is a large cell spanning the width of 'Cell 1' and 'Cell 2'. A label 'Interface element 406' points to the 'Add Cell' button, and 'Interface element 407' points to the 'Delete Cell' button. At the bottom of the grid area, there is a note: 'Press and hold the pointer on a cell to assign further cell properties such as default application.'

Native Screen 310 External Screen 312

Selected Screen External Screen 1

Interface element 408

Select a Grid Cell Resolution

☐ 320x240 ☐ 800x600 ☐ Auto-Fit
☐ 640x480 ☐ 1024x768
☐ Custom: Width Height

Interface element 406

Add Cell

Click Add Cell and then drag the cell into the position you want, then click the cell to lock into position

Delete Cell

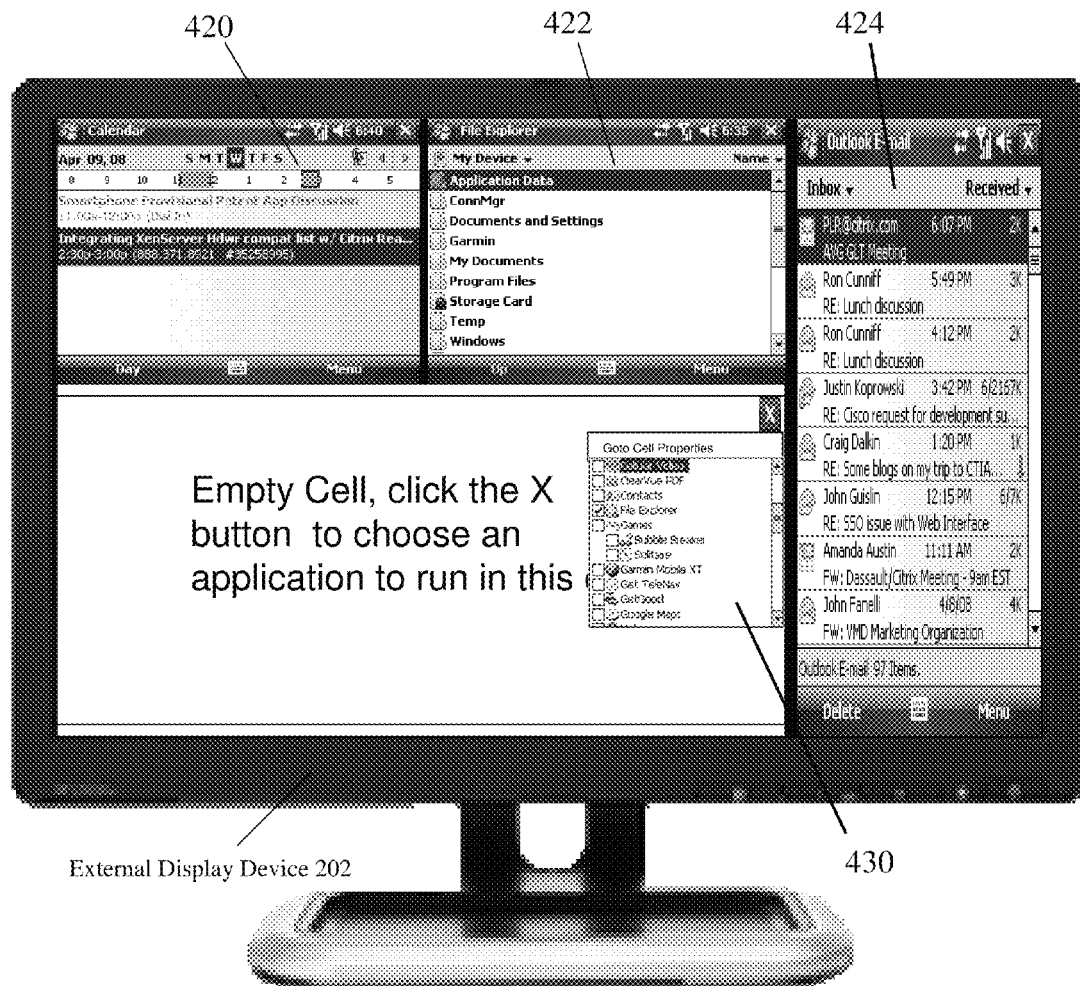
Select the cell you want to delete on the right, and select the Delete Cell button above.

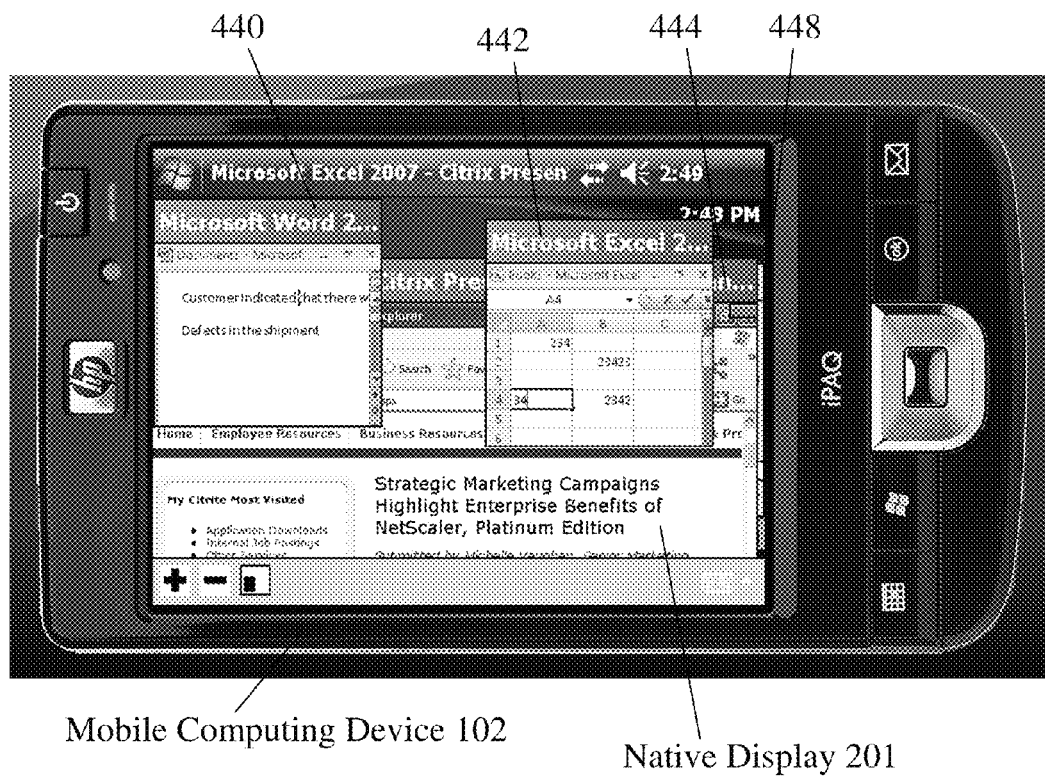
Interface element 407

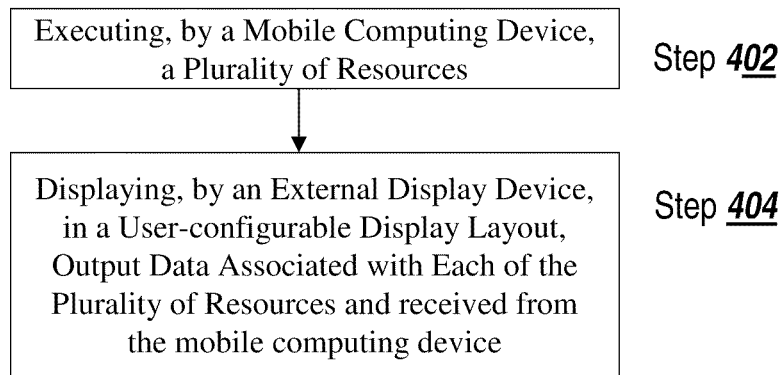
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|--------|--------|--------|
| Cell 1 | Cell 2 | Cell 3 |
| Cell 4 | | |

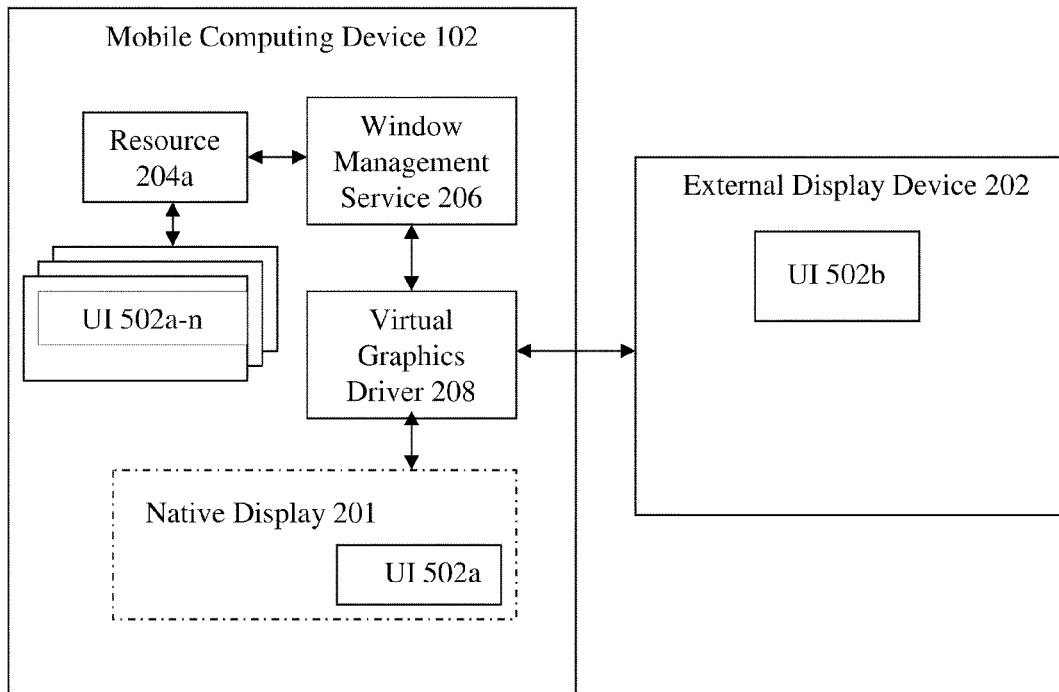
Press and hold the pointer on a cell to assign further cell properties such as default application.

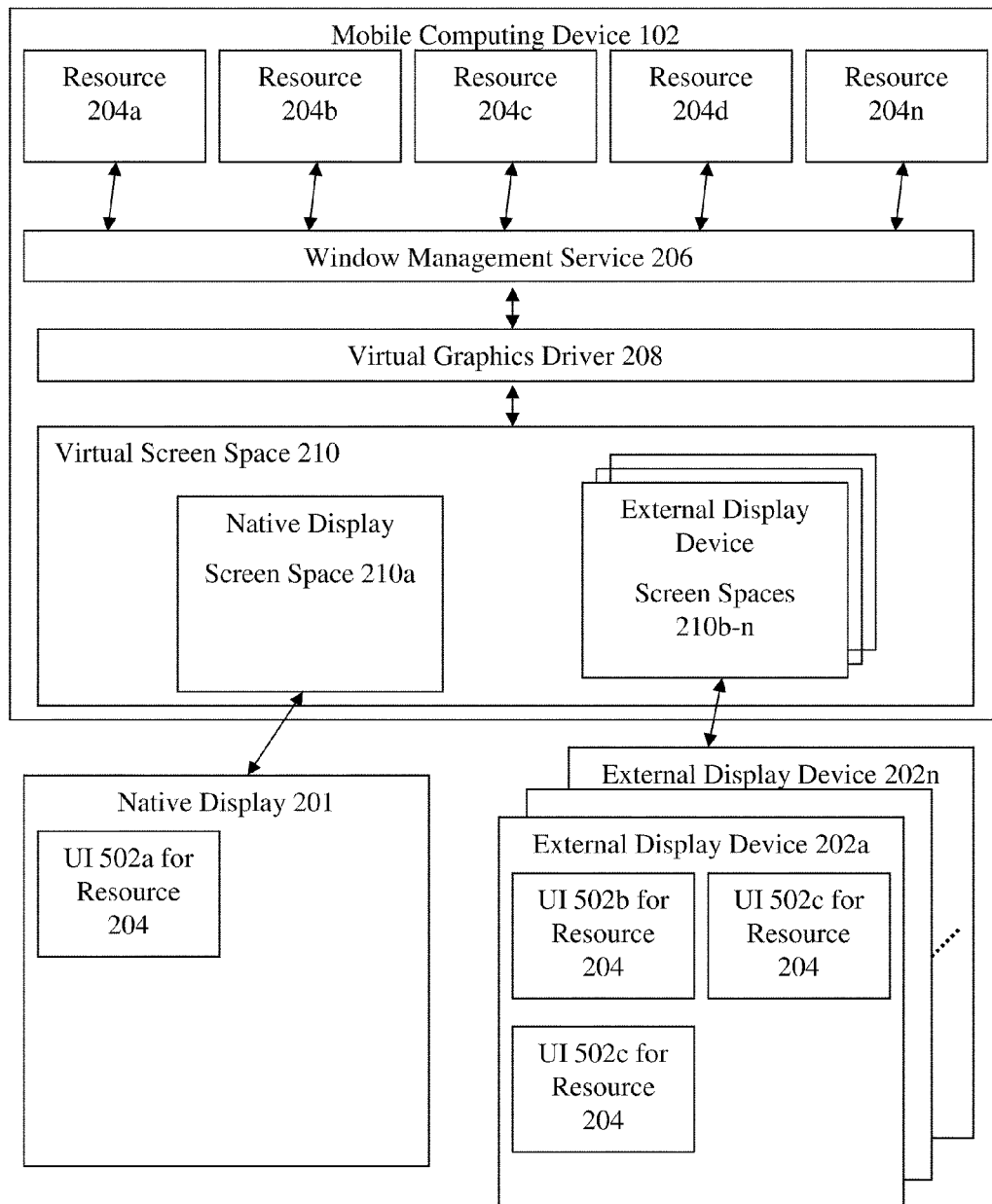
Fig. 4B

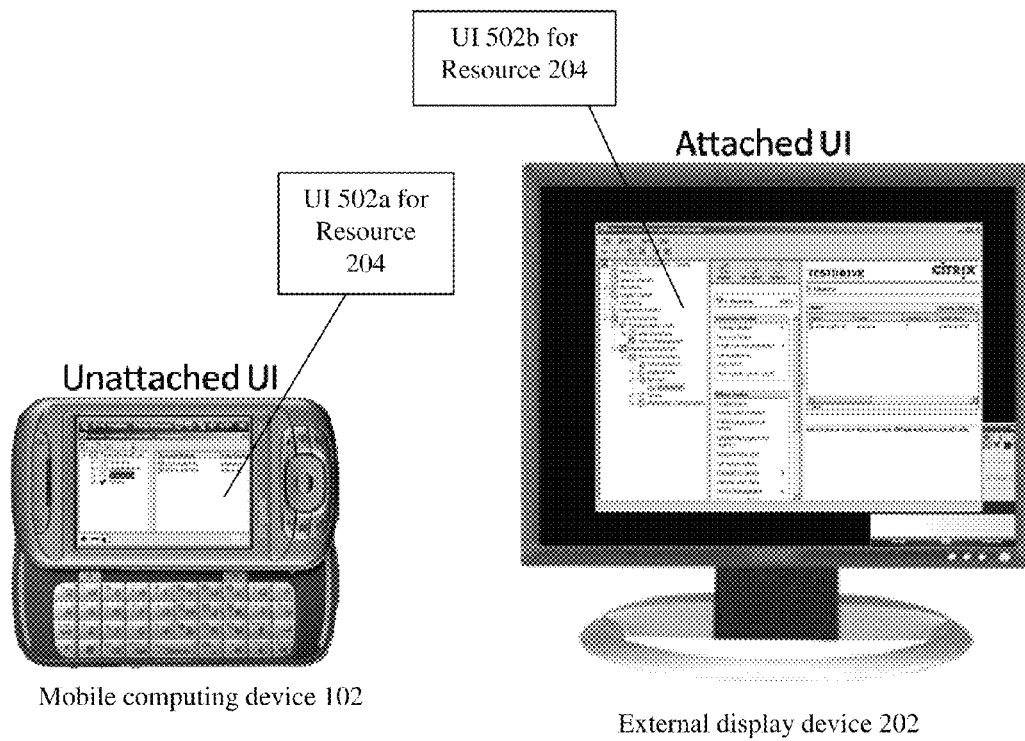
*Fig. 4C*

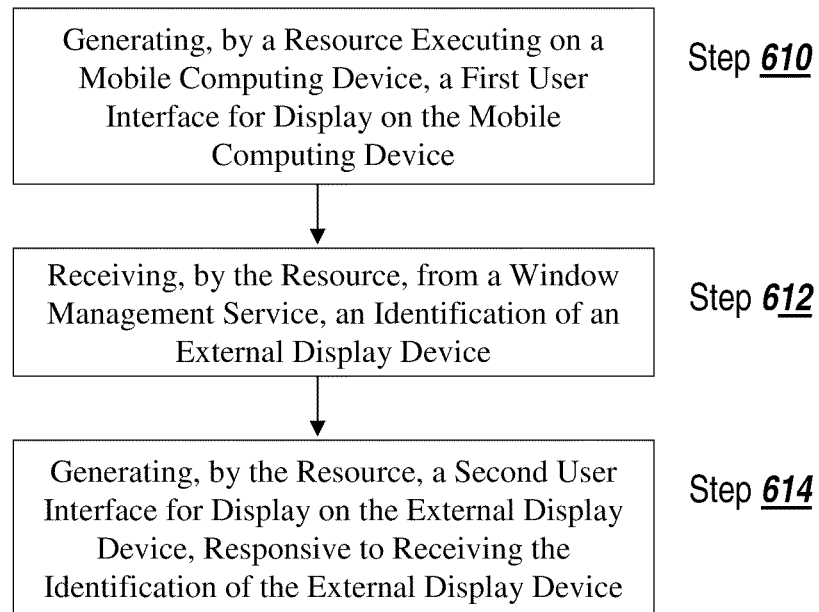
*Fig. 4D*

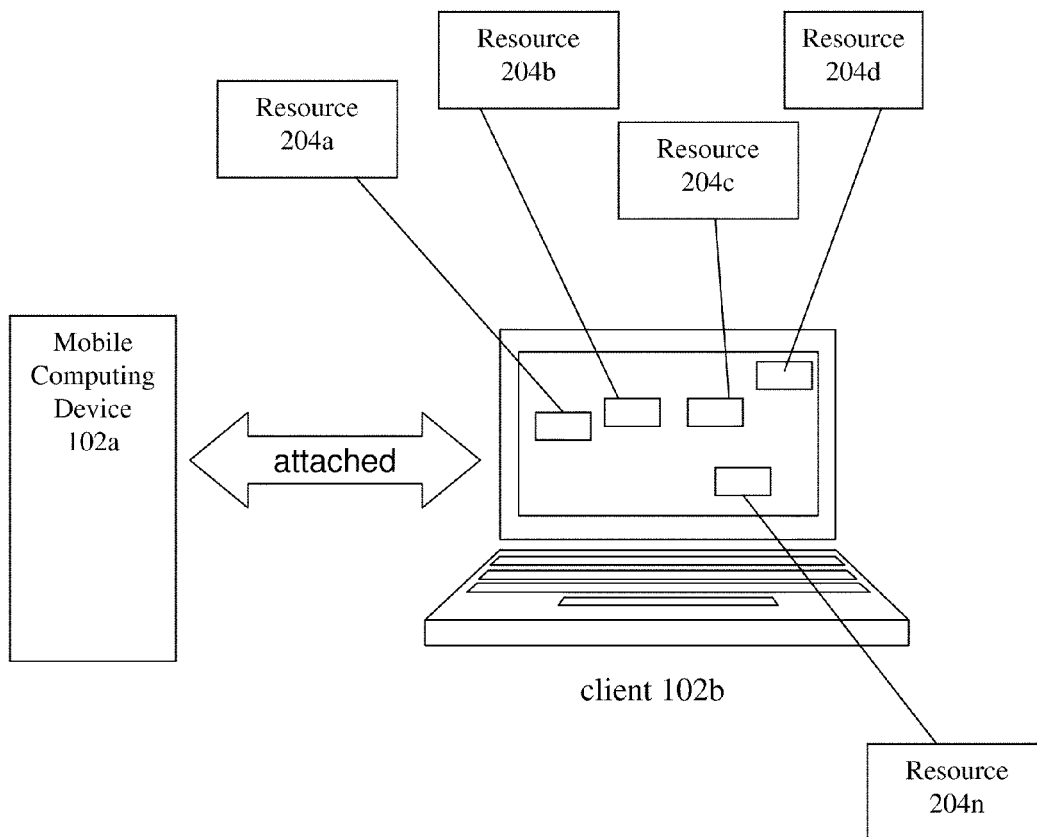
*Fig. 4E*

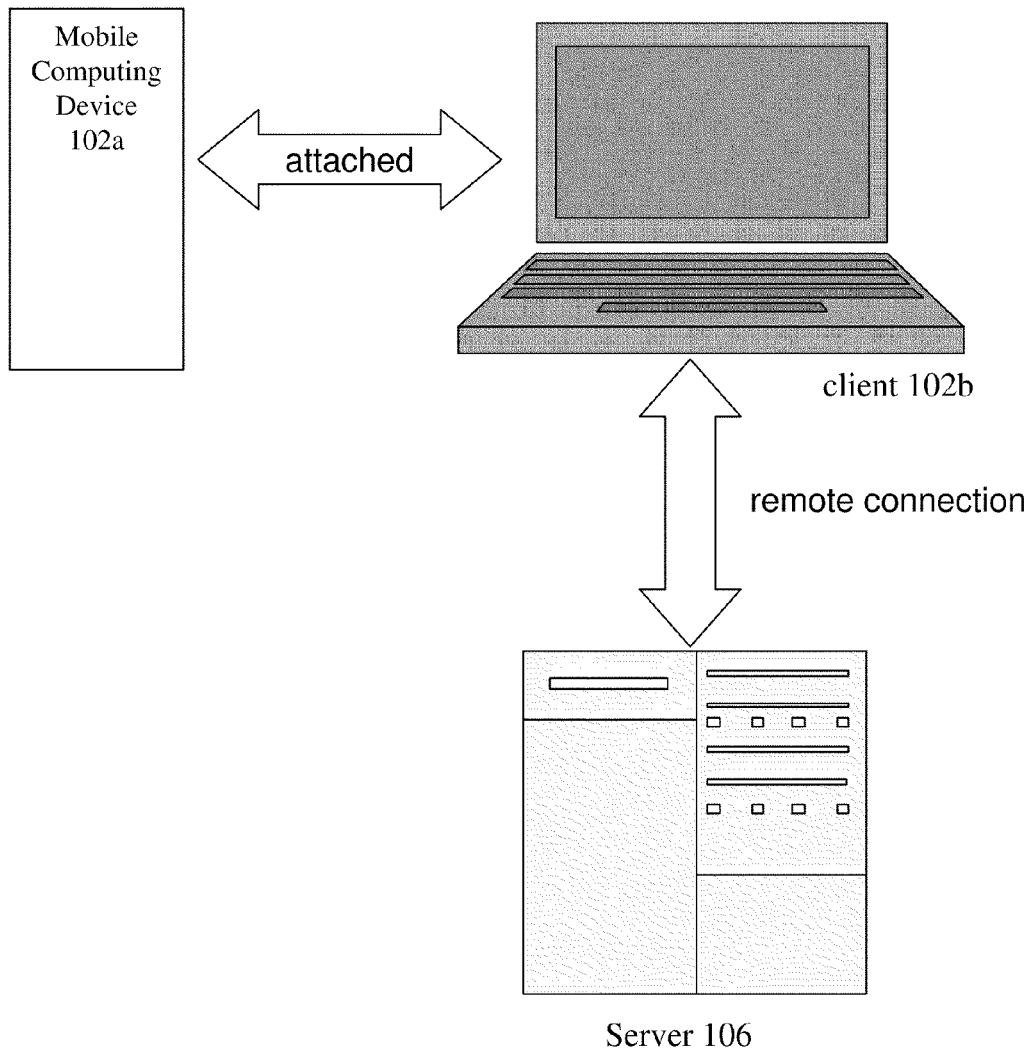
*Fig. 5A*

*Fig. 5B*

*Fig. 5C*

*Fig. 6*

*Fig. 7A*

*Fig. 7B*

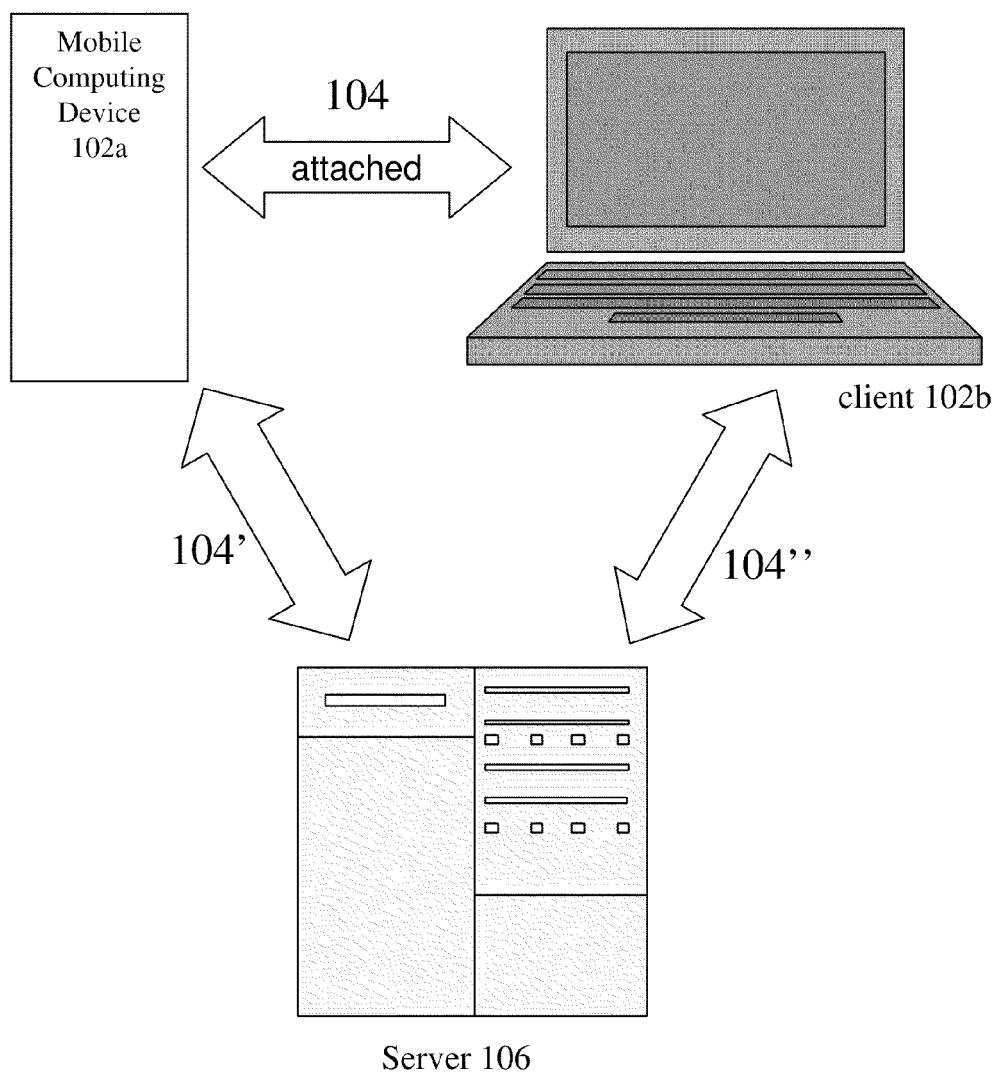
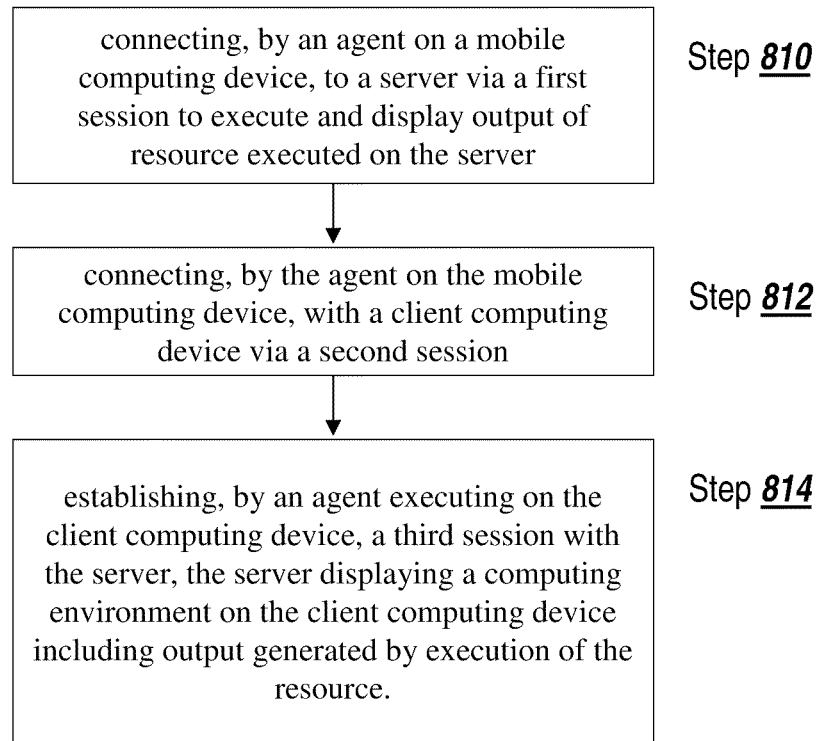
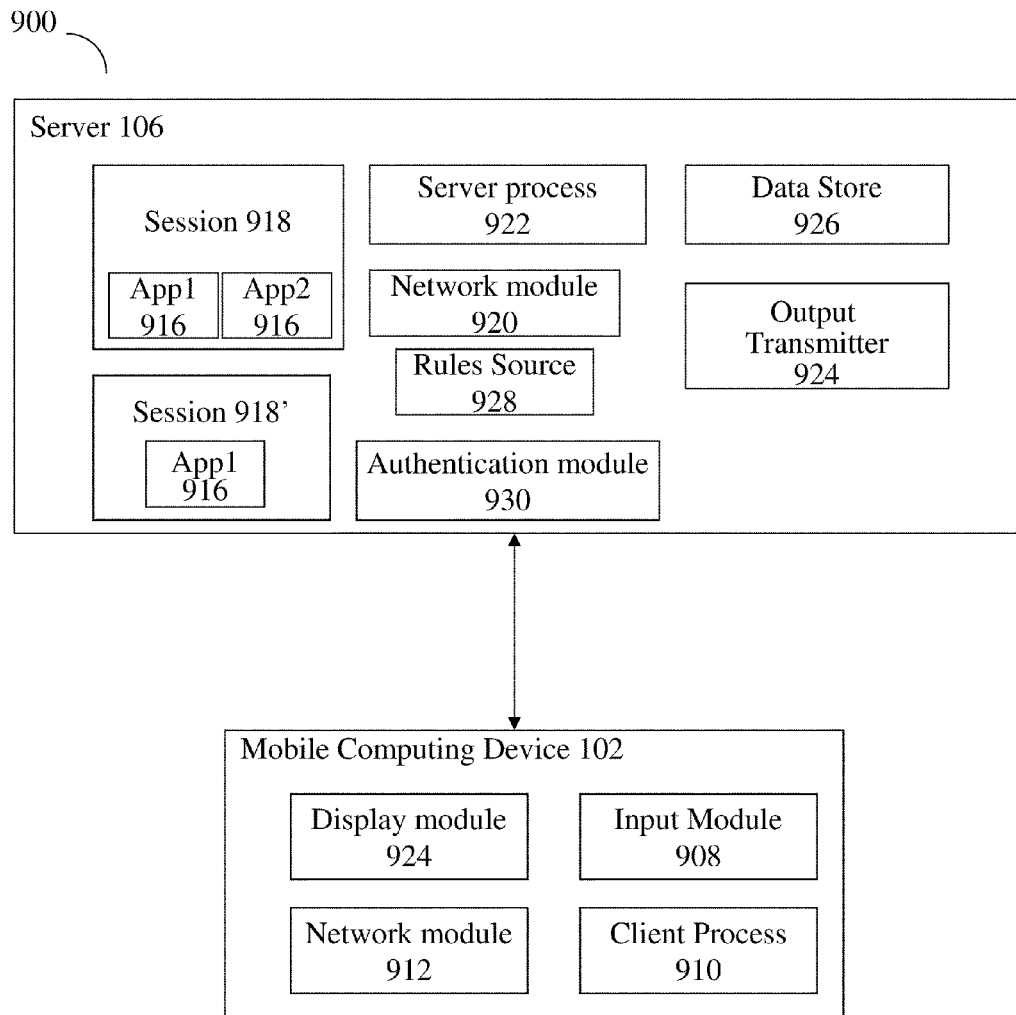
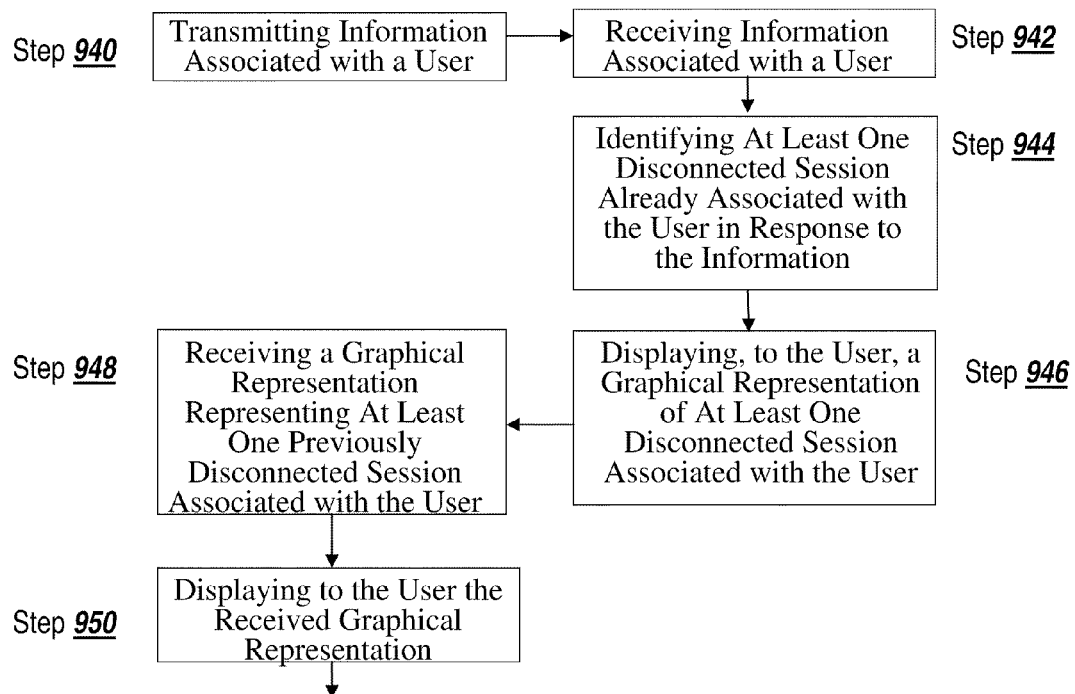
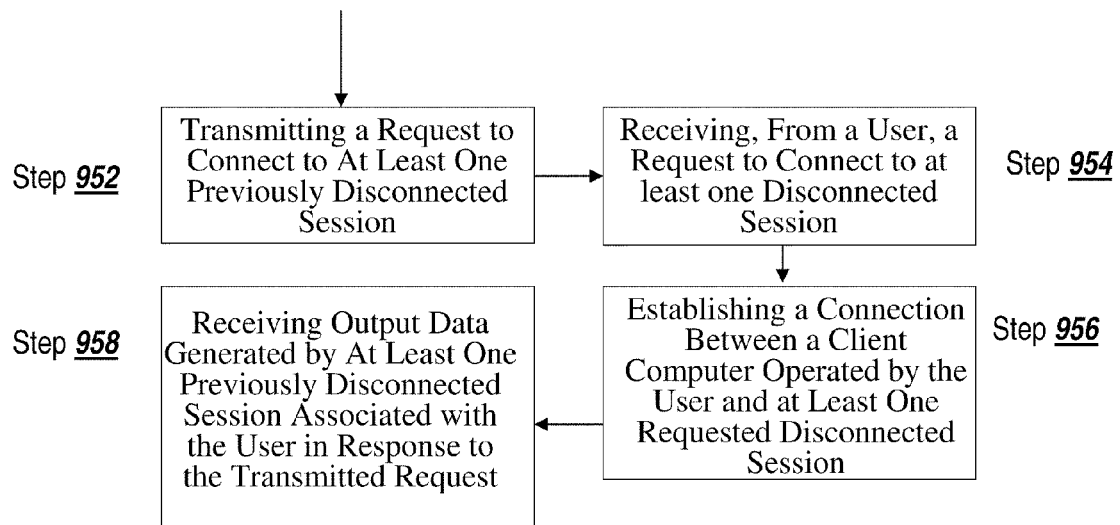


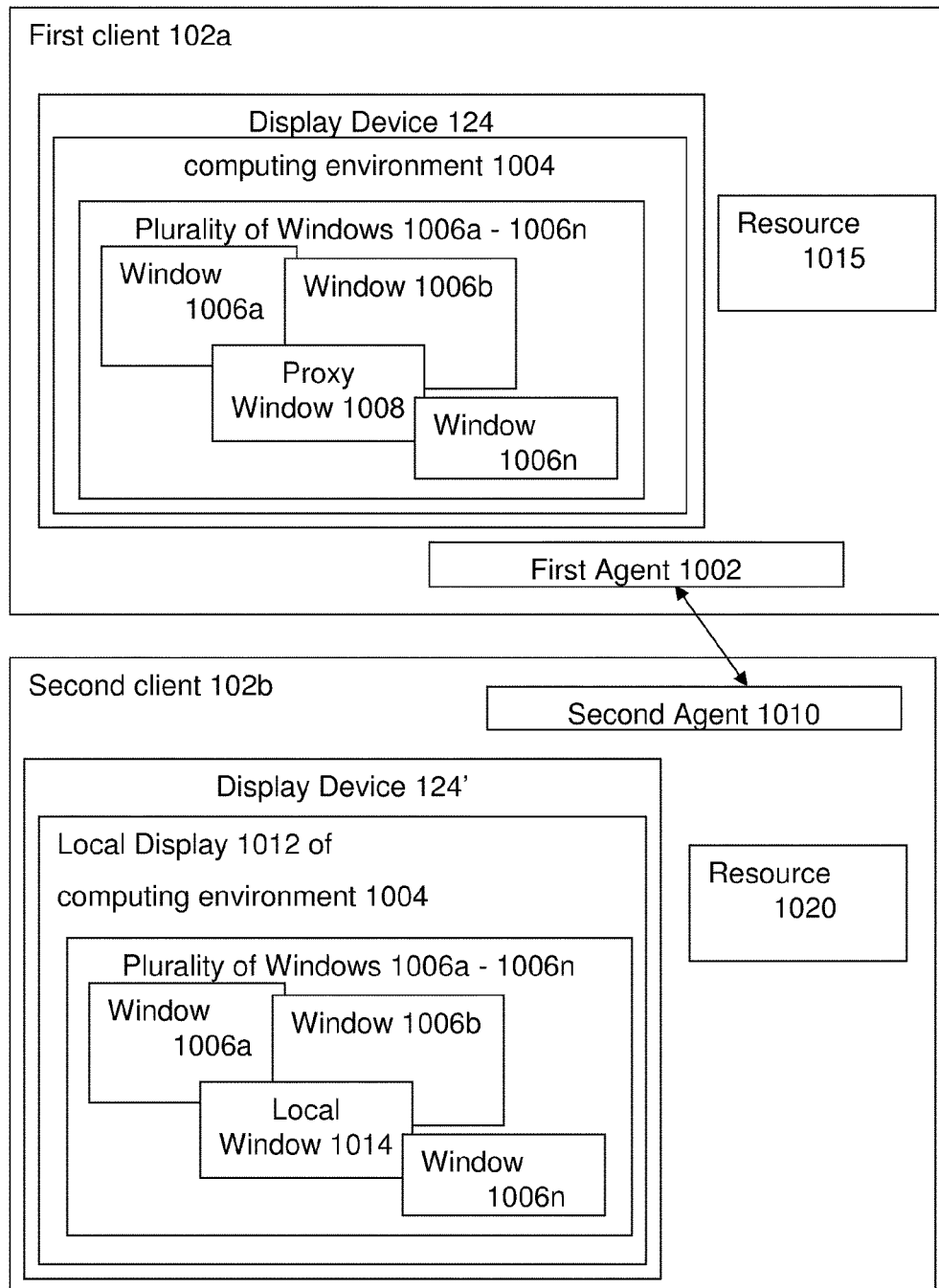
Fig. 8A

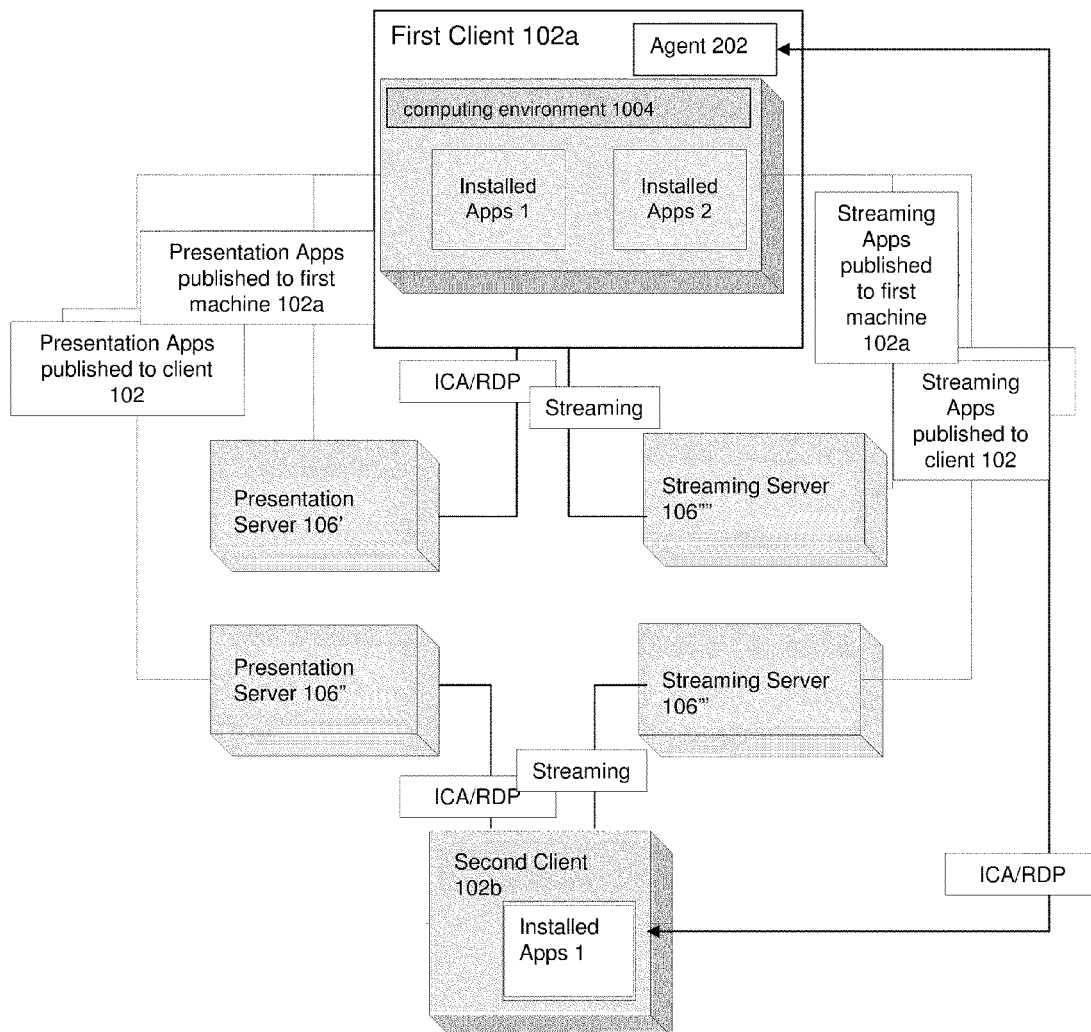
*Fig. 8B*

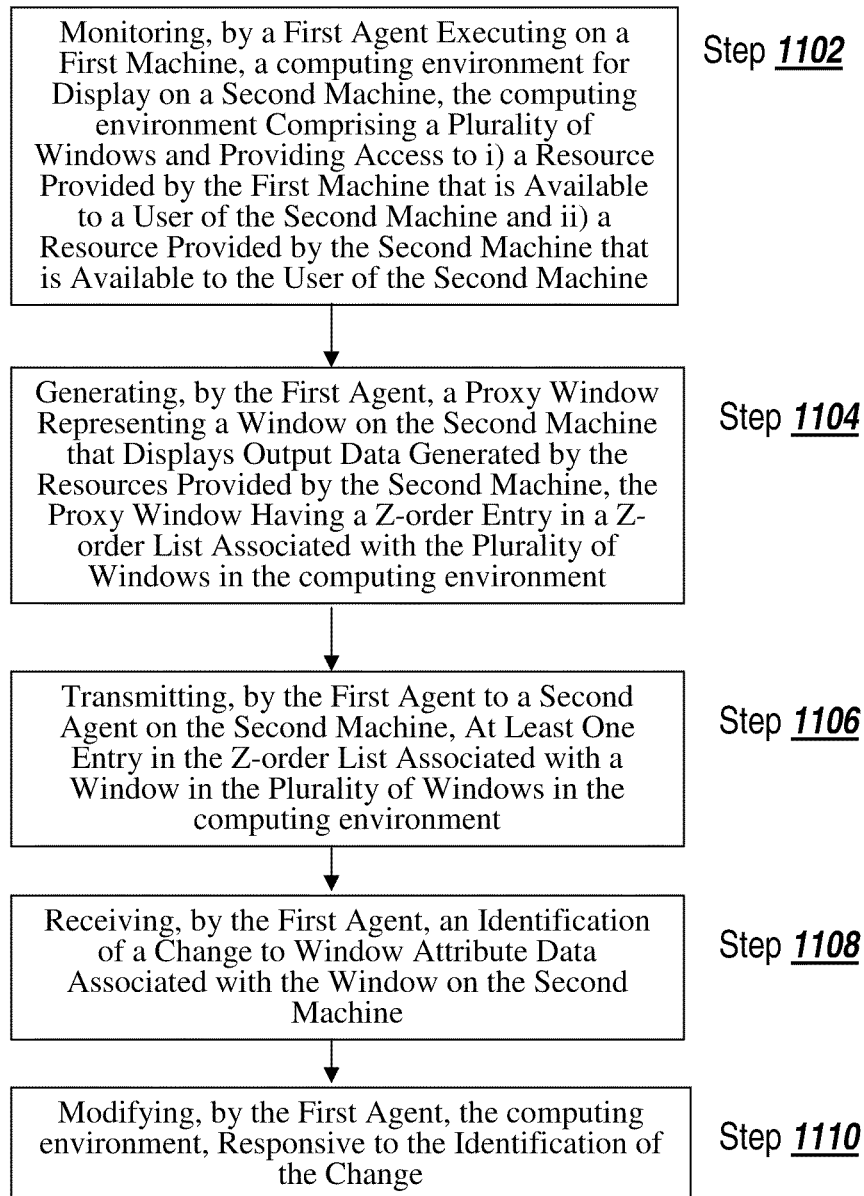
*Fig. 9A*

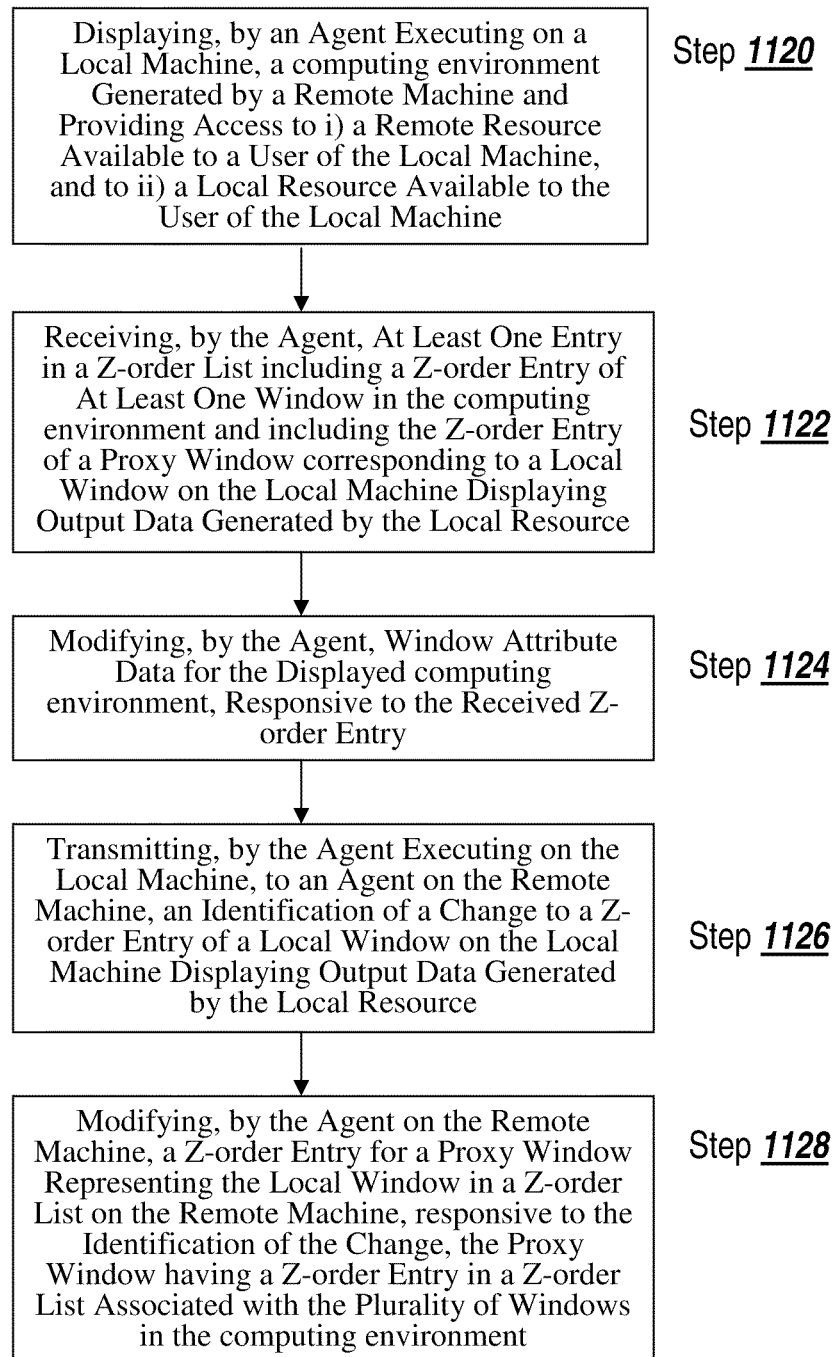
*Fig. 9B*

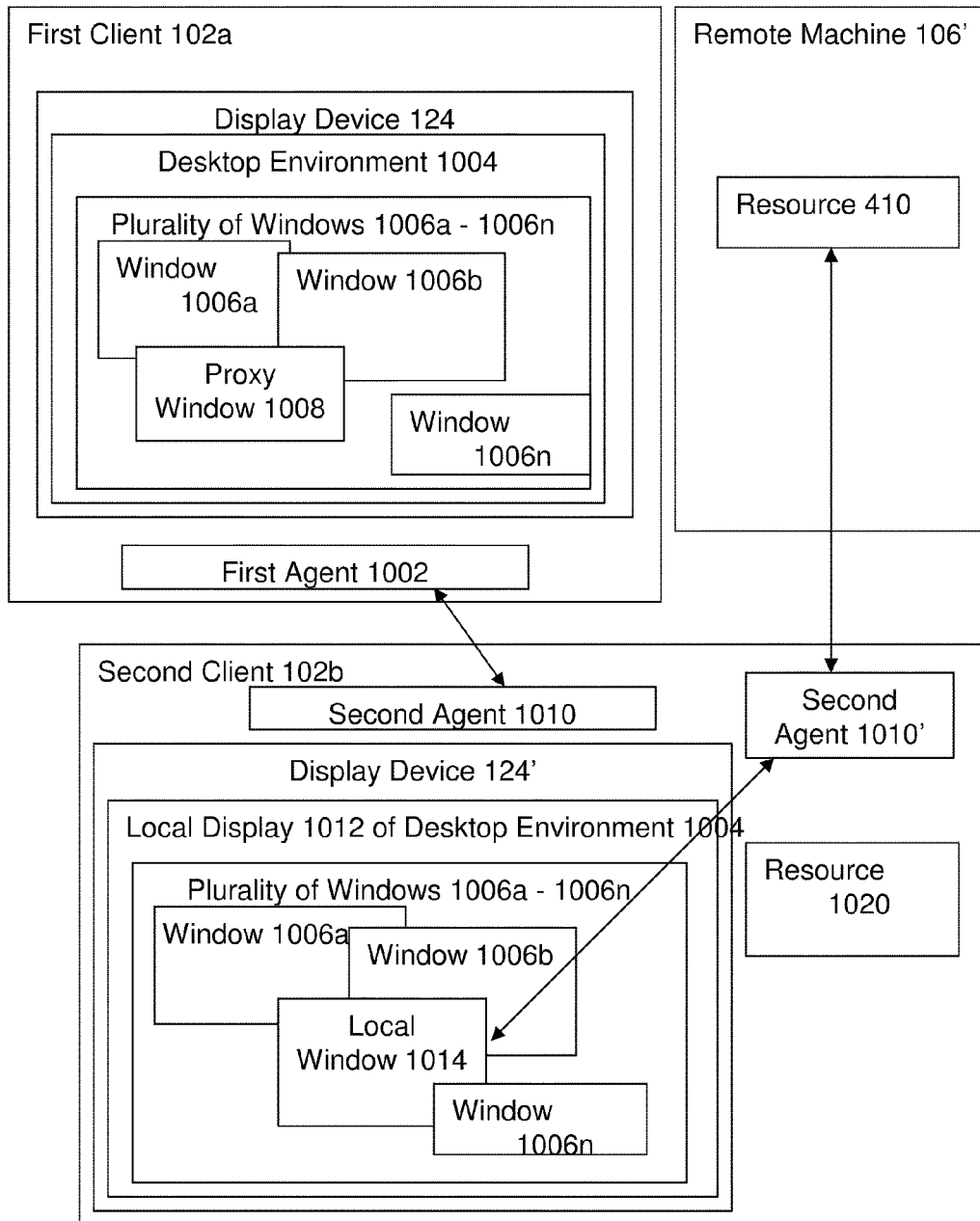
*Fig. 9C*

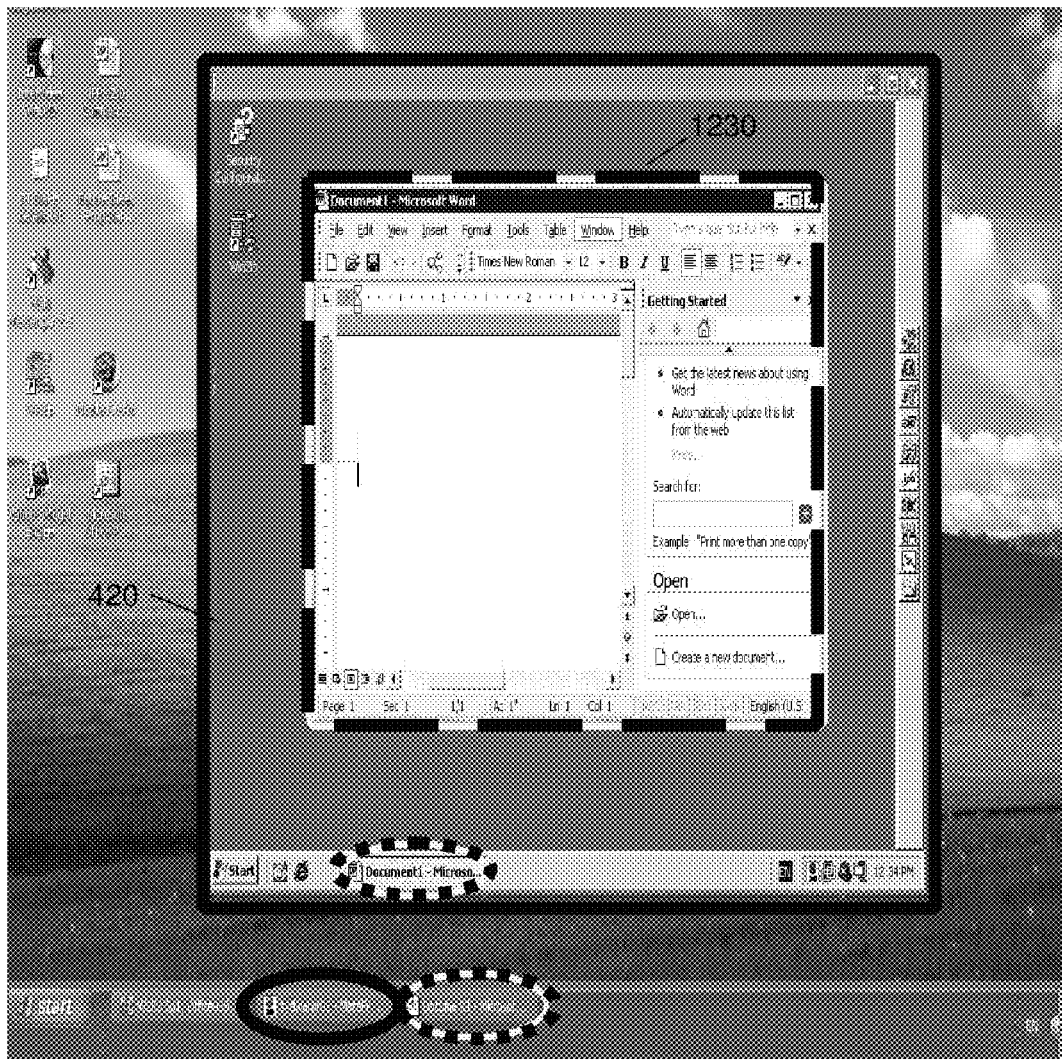
*Fig. 10A*

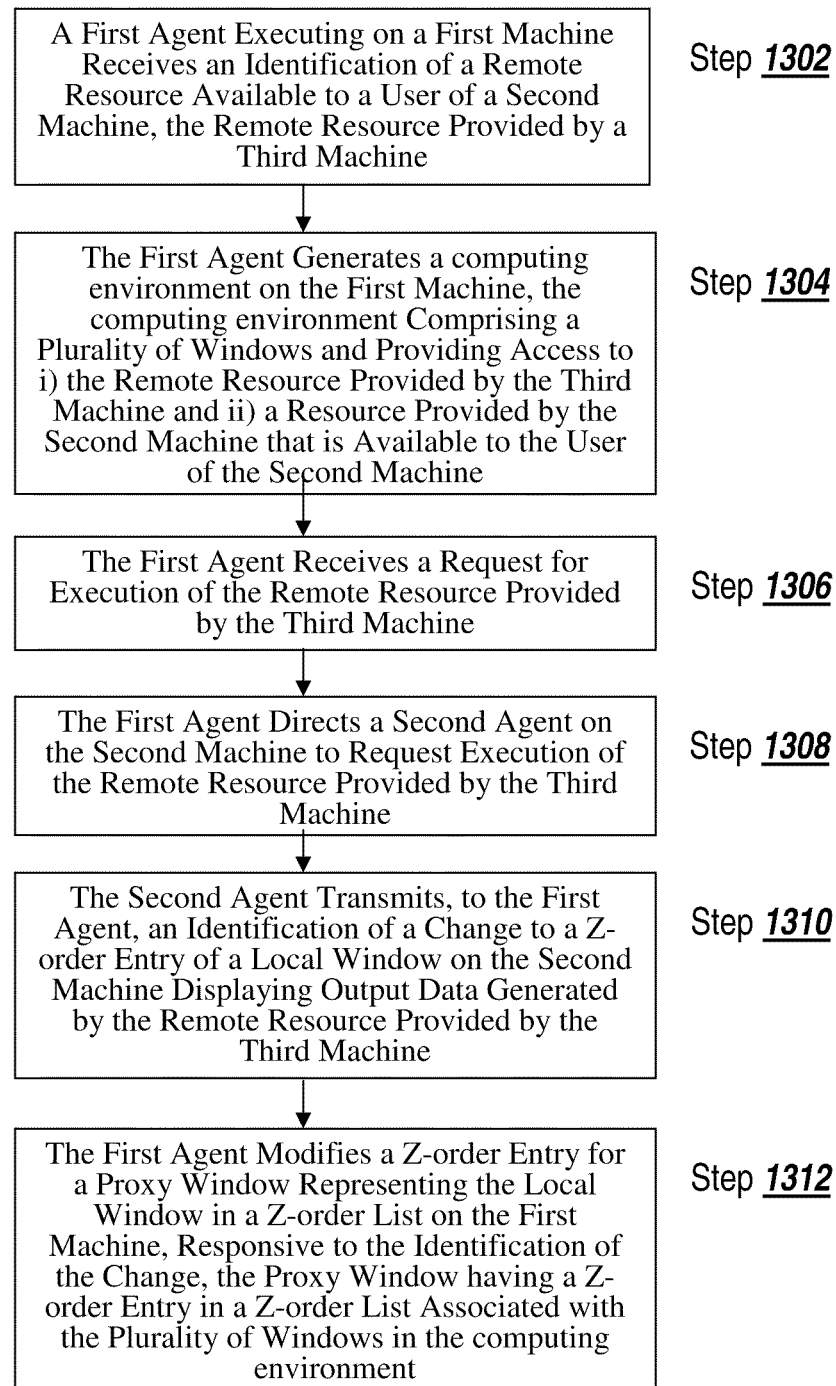
*Fig. 10B*

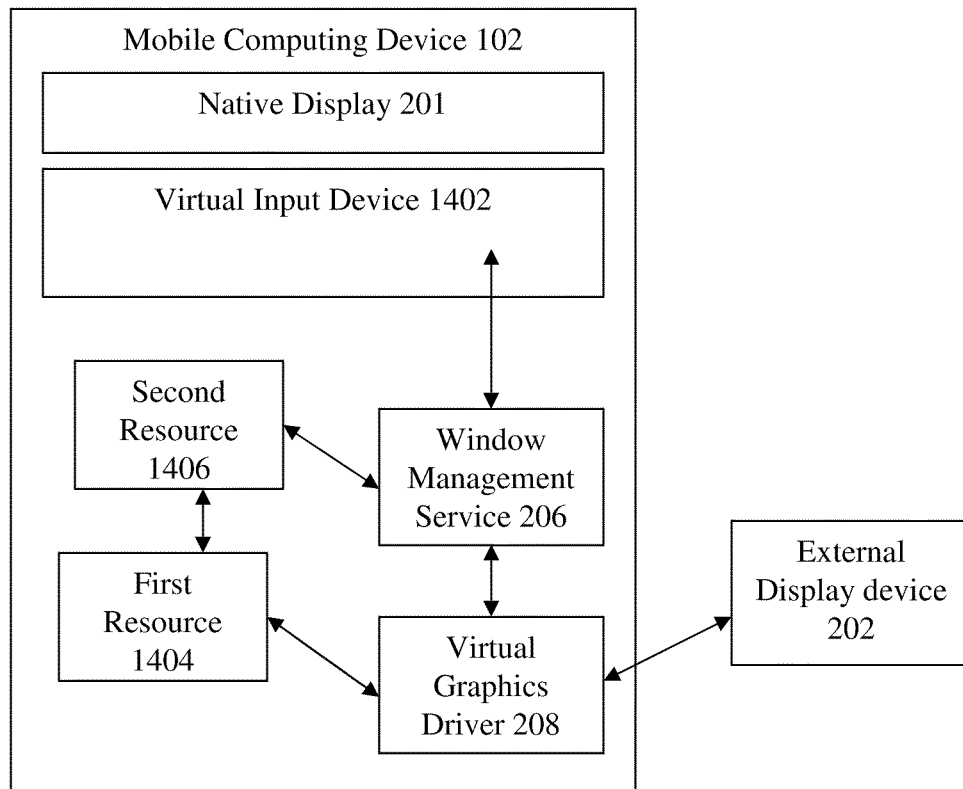
*Fig. 11A*

*Fig. 11B*

*Fig. 12A*

*Fig. 12B*

*Fig. 13*

*Fig. 14A*

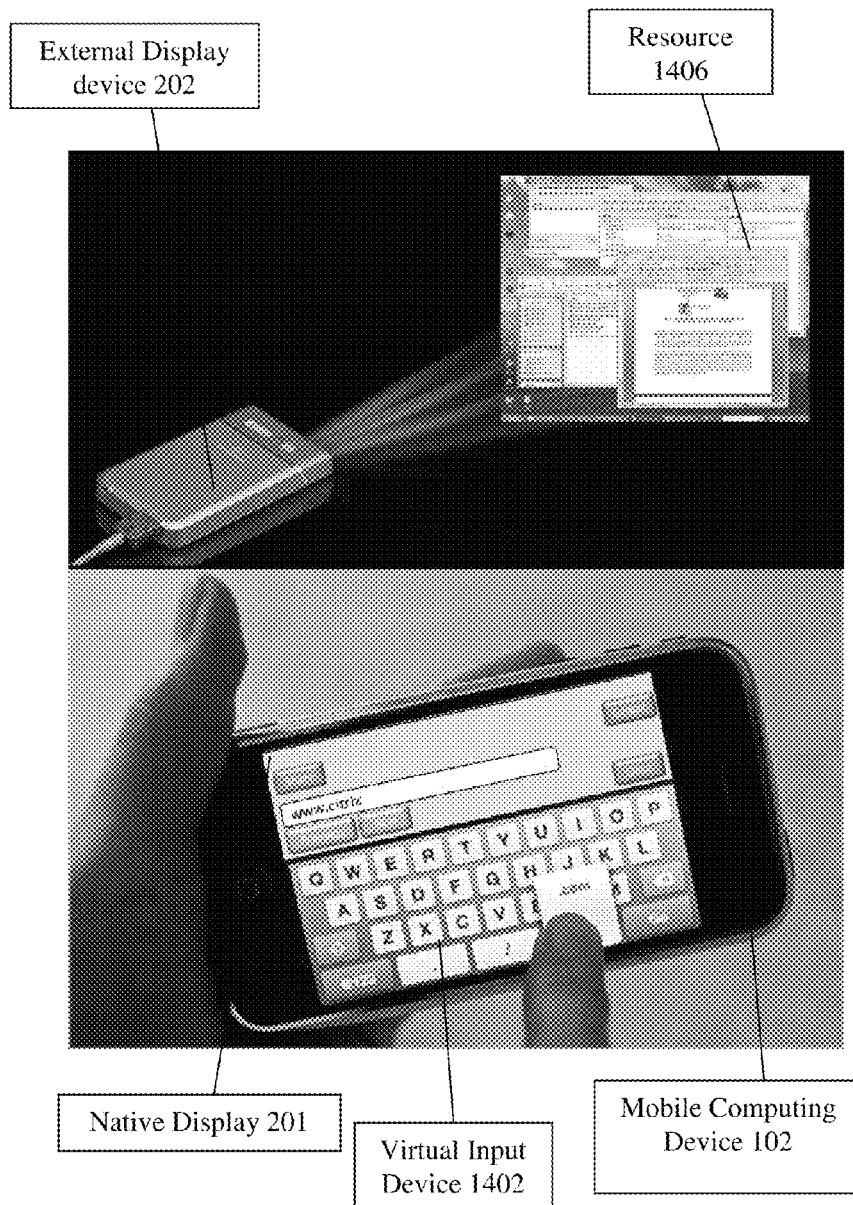


Fig. 14B

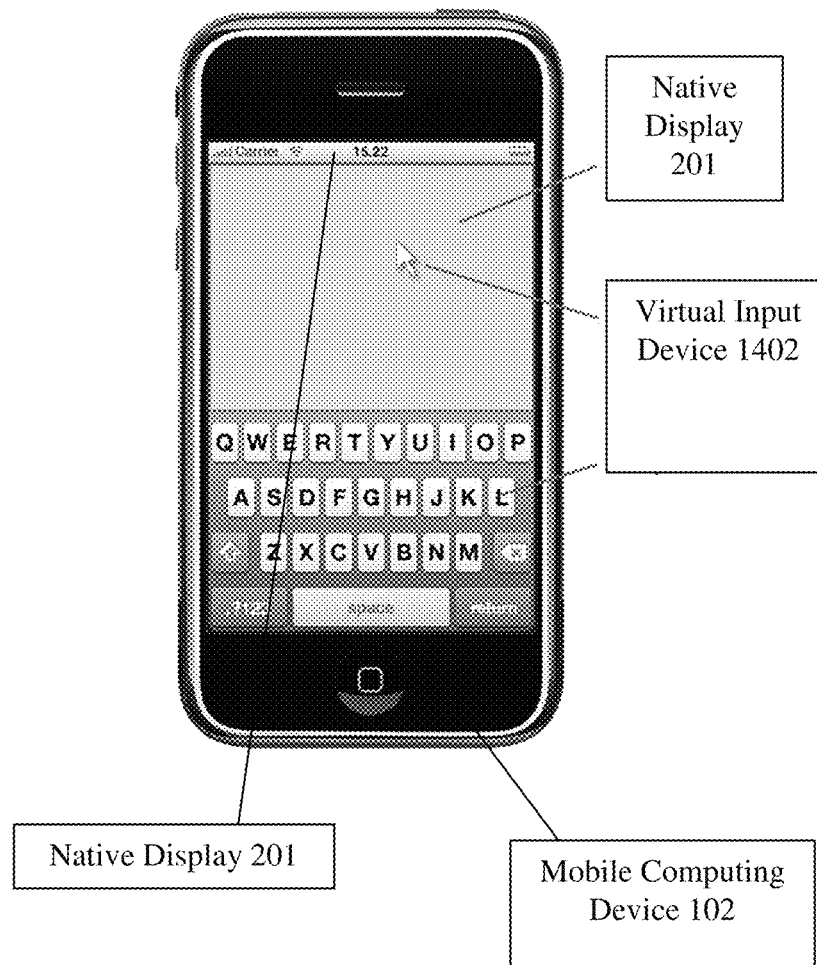
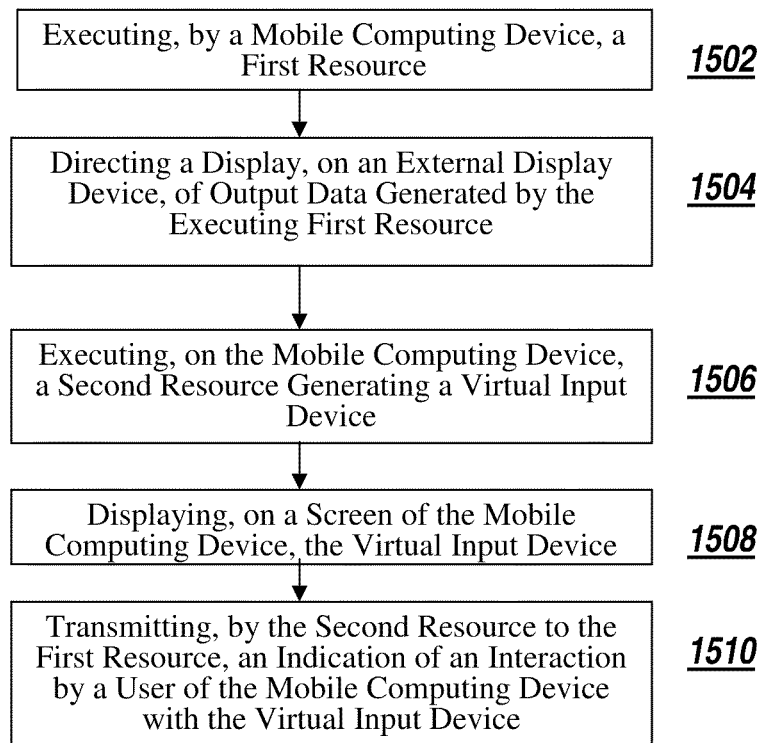


Fig. 14C

*Fig. 15*

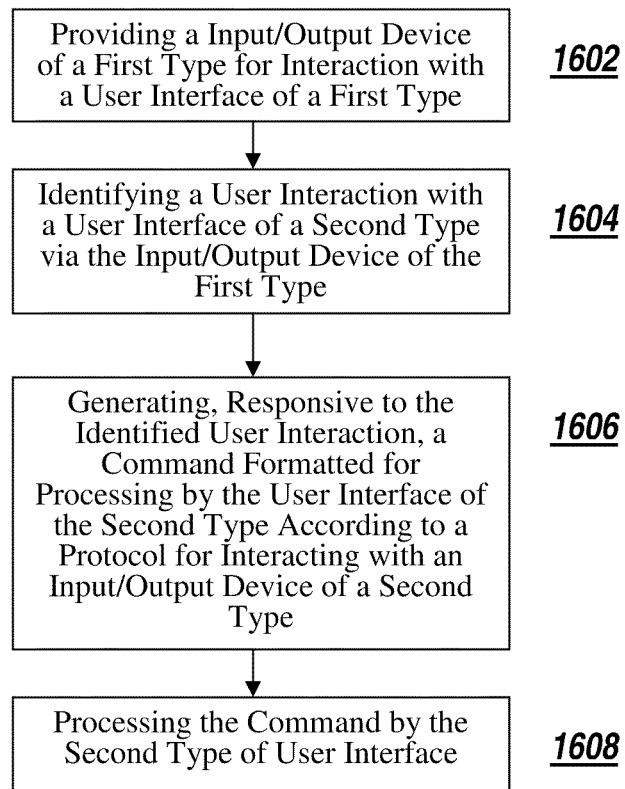


Fig. 16

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METHODS AND SYSTEMS FOR USING EXTERNAL DISPLAY DEVICES WITH A MOBILE COMPUTING DEVICE

FIELD OF THE INVENTION

The present disclosure relates to methods and systems for using external display devices with a mobile computing device. When an external display device is connected or attached to a mobile computing device, output data associated with a resource executing on the mobile computing device may be displayed on the external display device. The output data may include a user interface appropriate for the display of the external display device. Execution of the resource may be transferred from the mobile computing device to the external display device. The mobile computing device may be repurposed to display a virtual input device for interacting with a resource with output data being displayed on an external display device.

BACKGROUND OF THE INVENTION

With the pervasiveness of computers, network access, and Internet usage in daily personal and business-related activities, many users desire mobility and flexibility in their computing activities. As users physically move from location to location, and shift from activity to activity, they typically seek convenience and familiarity in performing computing activities. Users may carry one or more mobile computing devices—such as a smartphone, personal digital assistant, laptop or notebook computer—to provide a personalized computing experience as they move from location to location. Many users also use a portable storage device, such as a flash drive, to carry files, documents or applications in a convenient and portable manner. With such a storage device, a user accesses desired files or documents from publicly available computers to which the portable storage device can connect.

Many widely available modern computer desktop applications include rich graphical user interfaces (GUI) that have been developed for use on conventional personal computers, workstations, laptops, or other computing devices, typically have large displays, keyboard and mouse, etc. In contrast, mobile devices are often designed to be small enough to fit in a pocket, have relatively small displays, and some (often limited) means for data input such as telephone keypad, full keyboard, touch screen, stylus, etc. When it comes to supporting desktop or enterprise applications on mobile devices, limiting factors include the small display size and meager computational capacity. Various methods have been developed to run some desktop applications on mobile devices, but the results typically range from cumbersome and clumsy to not feasible or cost-prohibitive. The most common examples include rewriting applications, in whole or in part, to accommodate mobile device limitations, providing limited or “lite” versions of applications, scaling the application’s graphics to fit on the mobile device display, and using zooming and scrolling to turn the mobile device display into a “virtual lens” to view sub-regions of the application at a time.

BRIEF SUMMARY OF THE INVENTION

By enabling mobile computing devices to leverage external display devices, users may continue to benefit from a small form factor device’s portability and convenience without sacrificing quality of display or resource capabilities. Transferring a resource’s display from a mobile computing device to an external display device and selecting a user

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interface optimized for the external display can greatly improve a user’s comfort and ease while using the resource. Repurposing the mobile computing device as an input device for the external display minimally disrupts a user’s work since the repurposing eliminates the need to obtain and configure additional devices that interact with the external display device. Further, by accessing the external display device’s superior computational capacity, a user may run resources with complex and desired features without being constrained by the mobile computing device’s own limitations.

In one aspect, a method for displaying, on an external display device connected to a mobile computing device, output data associated with at least one resource. The method includes the step of receiving, by a virtual graphics driver on the mobile computing device, an identification of an external display device connected to the mobile computing device. The method includes the step of selecting, by a window management service on the mobile computing device according to the identification, at least one resource to display on the external display device. The method includes the step of positioning, by the window management service, output data associated with the at least one resource in a virtual screen space. The method includes the step of transmitting, by the virtual graphics driver, the output data to the external display device according to the virtual screen space.

In some embodiments, the method includes the step of allocating, by the window management service, a screen space corresponding to the external display device in the virtual screen space according to the identification. In some embodiments, the method includes the step of allocating, by the window management service, the screen space corresponding to the external display device according to a resolution of the external display device. In some embodiments, the method includes the step of removing, by the window management service, output data associated with the at least one resource from a position in the virtual screen space corresponding to a native display of the mobile computing device. In some embodiments, the method includes the step of positioning, by the window management service, the output data in the virtual screen space according to a type of the resource. In some embodiments, the method includes the step of positioning, by the window management service, the output data in the virtual screen space according to a user association between the resource and a cell in a grid display layout. In some embodiments, the method includes the step of positioning, by the window management service, the output data in the virtual screen space according to a policy associated with cells in a grid display layout. In some embodiments, the method includes the step of re-positioning, by the window management service, the output data in the virtual screen space according to an alteration of a grid display layout. In some embodiments, the method includes the step of positioning, by the window management service, the output data in the virtual screen space according to a user command to display the output data in an empty cell. In some embodiments, the method includes the step of positioning, by the window management service, the output data in the virtual screen space according to a policy associated with a dynamic display layout. In some embodiments, the method includes the step of positioning, by the window management service, the output data in the virtual screen space according to a default position associated with the resource. In some embodiments, the method includes the step of receiving, by the window management service, information associated with a user interaction with the output data. In some embodiments, the method includes the step of re-positioning, by the

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window management service, the output data according to the information associated with the user interaction. In some embodiments, the method includes the step of re-positioning, by the window management service, the output data to a position in the virtual screen space corresponding to a native display of the mobile computing device or a different external display device. In some embodiments, the method includes the step of obscuring, by the window management service, output data associated with a different resource. In some embodiments, the method includes the step of re-sizing, by the window management service, the output data associated with the resource.

In another aspect, a mobile computing device for displaying output data associated with at least one resource on an external display device. The mobile computing device also includes a window management service that selects, according to an identification of the external display device, the at least one resource to display on the external display device and positions output data associated with the at least one resource in a virtual screen space. The mobile computing device also includes a virtual graphics driver that transmits the output data to the external display device according to the virtual screen space. In some embodiments, the window management service allocates a screen space corresponding to the external display device in the virtual screen space according to the identification. In further embodiments, the window management service allocates a screen space corresponding to the external display device in the virtual screen space according to a resolution of the external display device. In additional embodiments, the window management service removes output data associated with the at least one resource from a position in the virtual screen space corresponding to a native display of the mobile computing device.

In yet another aspect, a method for displaying, on an external display device connected to a mobile computing device, a user interface for a resource. The method includes the step of receiving from the resource, by a window management service on the mobile computing device, a first user interface for display on a native display of the mobile computing device. The method also includes the step of transmitting, by a virtual graphics driver on the mobile computing device, the first user interface to the native display. The method also includes the step of transmitting, by the window management service, an identification of the external display device to the resource. The method also includes the step of receiving from the resource, by the window management service, a second user interface according to the identification, the second user interface being distinct from the first user interface. The method also includes the step of transmitting, by the virtual graphics driver, the second user interface to the external display device.

In some embodiments, the method includes the step of receiving from the resource, by the window management service, the second user interface optimized for the external display device. In more embodiments, the method includes the step of transmitting, by the window management service, at least one property of the external display device to the resource. In additional embodiments, the method includes the step of transmitting, by the window management service, an indication that a display on the external display device has a larger resolution or size than the native display. In many embodiments, the method includes the step of receiving from the resource, by the window management service, a default user interface in the absence of a user interface optimized for the external display device. In various embodiments, the method includes the step of receiving from the resource, by the window management service, a communication that a user interface optimized for the external display device is

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unavailable. In some embodiments, the method includes the step of transmitting, by the window management system, an identification of the second user interface and an instruction to display the second user interface to the external display device.

In another aspect, a method for transferring execution of a virtualized resource from a mobile computing device to an external display device. The method also includes the step of receiving, by a server from the mobile computing device, an identification of an external display device connected to the mobile computing device. The method also includes the step of identifying, by the server, a virtual machine being delivered to the external display device. The method also includes the step of disconnecting, by the server, the virtualized resource from a virtual machine being delivered to the mobile computing device. The method also includes the step of connecting, by the server, the virtualized resource to the virtual machine being delivered to the external display device.

In some embodiments, the virtualized resource is a virtualized application. In some embodiments, the method includes the step of transferring, by the server, information related to the state of execution of the virtualized resource from the virtual machine being delivered to the mobile computing device to the virtual machine being delivered to the external display device.

In another aspect, a method of repurposing a mobile computing device as a virtual input device for a first resource being displayed on an external display device. The method also includes the step of evaluating, by the server, input capabilities of the mobile computing device and input needs of the first resource. The method also includes the step of delivering according to the evaluation, by the server to the mobile computing device, a second resource that generates a virtual input device.

In some embodiments, the method includes the step of delivering, by the server to the mobile computing device, the second resource that generates a virtual keyboard, virtual track pad, virtual pointing device, virtual camera, virtual microphone, virtual point-of-sale device, virtual speaker, virtual headphone jack, or any combination thereof. In many embodiments, the method includes the step of delivering, by the server to the mobile computing device, the second resource that allows user interaction with output data of the first resource. In various embodiments, the method includes the step of delivering, by the server to the mobile computing device, the second resource that transmits an identification of a user interaction with the virtual input device to the first resource. In additional embodiments, the method includes the step of delivering, by the server to the mobile computing device, the second resource that generates at least one user interaction element. In some embodiments, the method includes the step of delivering, by the server to the mobile computing device, the second resource that redirects user interactions with the virtual input device to the input capabilities of the mobile computing device. In many embodiments, the method includes the step of delivering, by the server to the mobile computing device, the second resource that correlates a location of a touch input with a displayed user interaction element. In various embodiments, the method includes the step of delivering, by the server to the mobile computing device, a third resource that generates another virtual input device in conjunction with the virtual input device of the second resource. In some embodiments, the method includes the step of delivering, by the server to the mobile computing device, the second resource for display in conjunction with the first resource on a single display surface. In various embodiments, the method includes the step of

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delivering, by the server to the mobile computing device, the second resource that generates a virtual input device for a second external device connected to the mobile computing device.

In another aspect, a system for repurposing a mobile computing device as a virtual input device for a first resource being displayed on an external display device. The system also includes a server that evaluates input capabilities of the mobile computing device and input needs of the first resource and delivers to the mobile computing device, according to the evaluation, a second resource that generates a virtual input device.

In many embodiments, the second resource generates a virtual keyboard, virtual track pad, virtual pointing device, virtual camera, virtual microphone, virtual point-of-sale device, virtual speaker, virtual headphone jack, or any combination thereof. In some embodiments, the second resource allows user interaction with output data of the first resource. In additional embodiments, the second resource transmits an identification of a user interaction with the virtual input device to the first resource. In various embodiments, the second resource generates at least one user interaction element. In some embodiments, the second resource redirects user interactions with the virtual input device to the input capabilities of the mobile computing device. In many embodiments, the second resource correlates a location of a touch input with a displayed user interaction element. In many embodiments, the server delivers a third resource that generates another virtual input device in conjunction with the virtual input device of the second resource. In various embodiments, the second resource is displayed in conjunction with the first resource on a single display surface. In several embodiments, the second resource generates a virtual input device for a second external device connected to the mobile computing device.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, aspects, features, and advantages of the disclosure will become more apparent and better understood by referring to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1A is a block diagram depicting an embodiment of a network environment comprising client machines in communication with remote machines;

FIGS. 1B and 1C are block diagrams depicting embodiments of computers useful in connection with the methods and systems described herein;

FIG. 2A is a block diagram depicting one embodiment of a system for displaying a plurality of resources in a user-configurable display layout on an external display device;

FIG. 2B is a block diagram depicting a system for mapping a display of one or more resources to one or more display devices;

FIG. 2C is a screen shot depicting one embodiment of a system for displaying a plurality of resources in a user-configurable display layout on an external display device, the user-configurable display layout divided into a grid;

FIG. 2D is a screen shot depicting one embodiment of a system for displaying a plurality of resources in a user-configurable, dynamic display layout on an external display device;

FIG. 3A is a block diagram depicting one embodiment of a plurality of screen spaces provided by a mobile computing device attached to one or more external display devices;

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FIG. 3B is a block diagram depicting one embodiment of a mobile computing device providing a plurality of screen spaces;

FIG. 3C is a block diagram depicting one embodiment of a logical representation of a plurality of screen spaces managed by a virtual graphics driver;

FIG. 4A is a block diagram depicting one embodiment of a graphical user interface for the addition of and configuration of additional screen spaces;

FIG. 4B is a block diagram depicting one embodiment of a graphical user interface for customizing a grid display layout;

FIG. 4C is a screen shot depicting one embodiment of a customizable grid display layout;

FIG. 4D is a screen shot depicting one embodiment of unstacked displays on a mobile computing device;

FIG. 4E is a flow diagram depicting one embodiment of the steps taken in a method for displaying, by an external display device, output data generated by a plurality of resources executing on a mobile computing device;

FIG. 5A is a block diagram depicting one embodiment of a system for displaying, by an external display device, a first user interface to a resource distinct from a second user interface to the resource displayed by a mobile computing device executing the resource;

FIG. 5B is a block diagram depicting a system for mapping a display of one or more user interfaces to one or more display devices;

FIG. 5C is a screen shot depicting one embodiment of a system for displaying, by an external display device, a first user interface to an application distinct from a second user interface to the application displayed by a mobile computing device executing the application;

FIG. 6 is a flow diagram depicting an embodiment of the steps taken in a method for displaying, by an external display device, a first user interface to a resource distinct from a second user interface to the resource displayed by a mobile computing device executing the resource.

FIG. 7A is a block diagram depicting one embodiment of a system for executing and displaying a plurality of resources on a client computing device;

FIG. 7B is a block diagram depicting one embodiment of a system for executing a plurality of resources on a server and displaying them on a client computing device;

FIG. 8A is a block diagram of one embodiment of a system for executing a plurality of resources from a mobile computing device on a remote server and displaying results on a client computing device;

FIG. 8B is a flow diagram depicting one embodiment of the steps taken in a method for executing a plurality of resources from a mobile computing device on a remote server and displaying results on a client computing device;

FIG. 9A is a block diagram depicting one embodiment of a server for displaying and activating disconnected sessions with a mobile computing device and/or a client computing device;

FIG. 9B is a flow diagram depicting an embodiment of the steps taken in a method for receiving output data generated by the at least one previously disconnected session;

FIG. 9C is a flow diagram depicting one embodiment of the steps taken in a method for displaying and activating disconnected sessions with a mobile computing device and/or a client computing device;

FIG. 10A is a block diagram depicting an embodiment of a system for generating a computing environment on a remote machine for display on a local machine;

FIG. 10B is a block diagram depicting one embodiment of a system in which an agent integrates applications from various sources into a computing environment;

FIG. 11A is a flow diagram depicting one embodiment of the steps taken in a method for generating a computing environment on a remote machine for display on a local machine;

FIG. 11B is a flow diagram depicting one embodiment of the steps taken in a method for displaying, on the local machine, a desktop environment that is generated by the remote machine;

FIG. 12A is a block diagram depicting an embodiment of a system for generating a computing environment incorporating output data from multiple remote machines for display on a local machine;

FIG. 12B is a screen shot depicts one embodiment of a system for generating a computing environment incorporating output data from multiple remote machines for display on a local machine;

FIG. 13 is a flow diagram depicting one embodiment of a method for generating a computing environment incorporating output data from multiple remote machines for display on a local machine;

FIG. 14A is a block diagram depicting one embodiment of a system for displaying, on a screen of a mobile computing device, a virtual input device for interacting with a resource generating output data displayed on a display surface external to the mobile computing device;

FIGS. 14B and 14C are screen shots depicting an embodiment of a mobile computing device displaying a virtual input device for interaction by a user of the mobile computing device with a display of output data generated by an execution of a resource;

FIG. 15 is a flow diagram depicting one embodiment of a method for displaying, on a screen of a mobile computing device, a virtual input device for interacting with a resource generating output data displayed on a display surface external to the mobile computing device; and

FIG. 16 is a flow diagram depicting one embodiment of a method for translating a user interaction with an input/output device of a first type into a command for processing by a user interface supporting interaction with an input/output device of a second type.

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FIGS. 1A-1C relate to general computing devices and networks;

FIGS. 2A-4E relate to methods and systems for displaying resources executing on a mobile computing device in a user configurable layout on an external display;

FIGS. 5A-6 relate to dynamic switching between user interfaces;

FIGS. 7A-7B relate to methods and systems for displaying on a client computing device, output data generated by resources executed on the client computing device or a server;

FIGS. 8A-8B relate to methods and systems for displaying on a client computing device, output data generated by resources executed on a mobile computing device;

FIGS. 9A-9C relate to methods and systems for handling disconnected sessions between one or more of computing devices (included to support workspace control/smooth roaming aspects of a mobile computing device communicating with a server); and

FIGS. 10A-13 relate to methods and systems for generating a computing environment on one or more remote machines and displaying them on a local machine (included

to provide support for combining Nirvana techniques with reverse seamless subject matter).

FIGS. 14A-15 relate to methods and systems for displaying, on a screen of a mobile computing device, a virtual input device for interacting with a resource generating output data displayed on a display surface external to the mobile computing device.

FIG. 16 relates to methods and systems for translating a user interaction with an input/output device of a first type into a command for processing by a user interface supporting interaction with an input/output device of a second type.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1A, an embodiment of a network environment is depicted. In brief overview, the network environment comprises one or more clients 102a-102n (also generally referred to as local machine(s) 102, client(s) 102, client node(s) 102, client machine(s) 102, client computer(s) 102, client device(s) 102, endpoint(s) 102, or endpoint node(s) 102) in communication with one or more servers 106a-106n (also generally referred to as server(s) 106 or remote machine(s) 106) via one or more networks 104. In some embodiments, a client 102 has the capacity to function as both a client node seeking access to resources provided by a server and as a server providing access to hosted resources for other clients 102a-102n.

Although FIG. 1A shows a network 104 between the clients 102 and the servers 106, the clients 102 and the servers 106 may be on the same network 104. The network 104 can be a local-area network (LAN), such as a company Intranet, a metropolitan area network (MAN), or a wide area network (WAN), such as the Internet or the World Wide Web. In some embodiments, there are multiple networks 104 between the clients 102 and the servers 106. In one of these embodiments, a network 104' (not shown) may be a private network and a network 104 may be a public network. In another of these embodiments, a network 104 may be a private network and a network 104' a public network. In still another embodiment, networks 104 and 104' may both be private networks.

The network 104 may be any type and/or form of network and may include any of the following: a point to point network, a broadcast network, a wide area network, a local area network, a telecommunications network, a data communication network, a computer network, an ATM (Asynchronous Transfer Mode) network, a SONET (Synchronous Optical Network) network, a SDH (Synchronous Digital Hierarchy) network, a wireless network and a wireline network. In some embodiments, the network 104 may comprise a wireless link, such as an infrared channel or satellite band. The topology of the network 104 may be a bus, star, or ring network topology. The network 104 may be of any such network topology as known to those ordinarily skilled in the art capable of supporting the operations described herein. The network may comprise mobile telephone networks utilizing any protocol or protocols used to communicate among mobile devices, including AMPS, TDMA, CDMA, GSM, GPRS or UMTS. In some embodiments, different types of data may be transmitted via different protocols. In other embodiments, the same types of data may be transmitted via different protocols.

In some embodiments, the system may include multiple, logically-grouped servers 106. In one of these embodiments, the logical group of servers may be referred to as a server farm 38. In another of these embodiments, the servers 106 may be geographically dispersed. In other embodiments, a server farm 38 may be administered as a single entity. In still other embodiments, the server farm 38 comprises a plurality of

server farms 38. The servers 106 within each server farm 38 can be heterogeneous—one or more of the servers 106 can operate according to one type of operating system platform (e.g., WINDOWS NT, manufactured by Microsoft Corp. of Redmond, Wash.), while one or more of the other servers 106 can operate on according to another type of operating system platform (e.g., Unix or Linux).

The servers 106 of each server farm 38 do not need to be physically proximate to another server 106 in the same server farm 38. Thus, the group of servers 106 logically grouped as a server farm 38 may be interconnected using a wide-area network (WAN) connection or a metropolitan-area network (MAN) connection. For example, a server farm 38 may include servers 106 physically located in different continents or different regions of a continent, country, state, city, campus, or room. Data transmission speeds between servers 106 in the server farm 38 can be increased if the servers 106 are connected using a local-area network (LAN) connection or some form of direct connection.

Server 106 may be a file server, application server, web server, proxy server, appliance, network appliance, gateway, application gateway, gateway server, virtualization server, deployment server, SSL VPN server, or firewall. In some embodiments, a server 106 provides a remote authentication dial-in user service, and is referred to as a RADIUS server. In other embodiments, a server 106 may have the capacity to function as either an application server or as a master application server. In still other embodiments, a server 106 is a blade server. In yet other embodiments, a server 106 executes a virtual machine providing, to a user or client computer 102, access to a computing environment.

In one embodiment, a server 106 may include an Active Directory. The server 106 may be an application acceleration appliance. For embodiments in which the server 106 is an application acceleration appliance, the server 106 may provide functionality including firewall functionality, application firewall functionality, or load balancing functionality. In some embodiments, the server 106 comprises an appliance such as one of the line of appliances manufactured by the Citrix Application Networking Group, of San Jose, Calif., or Silver Peak Systems, Inc., of Mountain View, Calif., or of Riverbed Technology, Inc., of San Francisco, Calif., or of F5 Networks, Inc., of Seattle, Wash., or of Juniper Networks, Inc., of Sunnyvale, Calif.

In some embodiments, a server 106 executes an application on behalf of a user of a client 102. In other embodiments, a server 106 executes a virtual machine, which provides an execution session within which applications execute on behalf of a user or a client 102. In one of these embodiments, the execution session is a hosted desktop session. In another of these embodiments, the execution session provides access to a computing environment, which may comprise one or more of: an application, a plurality of applications, a desktop application, and a desktop session in which one or more applications may execute.

In some embodiments, a client 102 communicates with a server 106. In one embodiment, the client 102 communicates directly with one of the servers 106 in a server farm 38. In another embodiment, the client 102 executes a program neighborhood application to communicate with a server 106 in a server farm 38. In still another embodiment, the server 106 provides the functionality of a master node. In some embodiments, the client 102 communicates with the server 106 in the server farm 38 through a network 104. Over the network 104, the client 102 can, for example, request execution of various applications hosted by the servers 106a-106n in the server farm 38 and receive output of the results of the

application execution for display. In some embodiments, only the master node provides the functionality required to identify and provide address information associated with a server 106b hosting a requested application.

In one embodiment, the server 106 provides the functionality of a web server. In another embodiment, the server 106a receives requests from the client 102, forwards the requests to a second server 106b and responds to the request by the client 102 with a response to the request from the server 106b. In still another embodiment, the server 106 acquires an enumeration of applications available to the client 102 and address information associated with a server 106' hosting an application identified by the enumeration of applications. In yet another embodiment, the server 106 presents the response to the request to the client 102 using a web interface. In one embodiment, the client 102 communicates directly with the server 106 to access the identified application. In another embodiment, the client 102 receives output data, such as display data, generated by an execution of the identified application on the server 106.

In some embodiments, the server 106 or a server farm 38 may be running one or more applications, such as an application providing a thin-client computing or remote display presentation application. In one embodiment, the server 106 or server farm 38 executes as an application any portion of the CITRIX ACCESS SUITE by Citrix Systems, Inc., such as the METAFRAME or CITRIX PRESENTATION SERVER and/or any of the MICROSOFT WINDOWS Terminal Services manufactured by the Microsoft Corporation. In another embodiment, the application is an ICA client, developed by Citrix Systems, Inc. of Fort Lauderdale, Fla. In still another embodiment, the server 106 may run an application, which, for example, may be an application server providing email services such as MICROSOFT EXCHANGE manufactured by the Microsoft Corporation of Redmond, Wash., a web or Internet server, or a desktop sharing server, or a collaboration server. In yet another embodiment, any of the applications may comprise any type of hosted service or products, such as GOTOMEETING provided by Citrix Online Division, Inc. of Santa Barbara, Calif., WEBEX provided by WebEx, Inc. of Santa Clara, Calif., or Microsoft Office LIVE MEETING provided by Microsoft Corporation of Redmond, Wash.

A client 102 may execute, operate or otherwise provide an application, which can be any type and/or form of software, program, or executable instructions such as any type and/or form of web browser, web-based client, client-server application, a thin-client computing client, an ActiveX control, or a Java applet, or any other type and/or form of executable instructions capable of executing on client 102. In some embodiments, the application may be a server-based or a remote-based application executed on behalf of the client 102 on a server 106. In one embodiment the server 106 may display output to the client 102 using any thin-client or remote-display protocol, such as the Independent Computing Architecture (ICA) protocol manufactured by Citrix Systems, Inc. of Ft. Lauderdale, Fla. or the Remote Desktop Protocol (RDP) manufactured by the Microsoft Corporation of Redmond, Wash. The application can use any type of protocol and it can be, for example, an HTTP client, an FTP client, an Oscar client, or a Telnet client. In other embodiments, the application comprises any type of software related to voice over internet protocol (VoIP) communications, such as a soft IP telephone. In further embodiments, the application comprises any application related to real-time data communications, such as applications for streaming video and/or audio.

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The client **102** and server **106** may be deployed as and/or executed on any type and form of computing device, such as a computer, network device or appliance capable of communicating on any type and form of network and performing the operations described herein. FIGS. **1B** and **1C** depict block diagrams of a computing device **100** useful for practicing an embodiment of the client **102** or a server **106**. As shown in FIGS. **1B** and **1C**, each computing device **100** includes a central processing unit **121**, and a main memory unit **122**. As shown in FIG. **1B**, a computing device **100** may include a storage device **128**, an installation device **116**, a network interface **118**, an I/O controller **123**, display devices **124a-n**, a keyboard **126** and a pointing device **127**, such as a mouse. The storage device **128** may include, without limitation, an operating system, software, and a client agent **120**. As shown in FIG. **1C**, each computing device **100** may also include additional optional elements, such as a memory port **103**, a bridge **170**, one or more input/output devices **130a-130n** (generally referred to using reference numeral **130**), and a cache memory **140** in communication with the central processing unit **121**.

The central processing unit **121** is any logic circuitry that responds to and processes instructions fetched from the main memory unit **122**. In many embodiments, the central processing unit **121** is provided by a microprocessor unit, such as: those manufactured by Intel Corporation of Mountain View, Calif.; those manufactured by Motorola Corporation of Schaumburg, Ill.; those manufactured by Transmeta Corporation of Santa Clara, Calif.; the RS/6000 processor, those manufactured by International Business Machines of White Plains, N.Y.; or those manufactured by Advanced Micro Devices of Sunnyvale, Calif. The computing device **100** may be based on any of these processors, or any other processor capable of operating as described herein.

Main memory unit **122** may be one or more memory chips capable of storing data and allowing any storage location to be directly accessed by the microprocessor **121**, such as Static random access memory (SRAM), Burst SRAM or Synch-Burst SRAM (BSRAM), Dynamic random access memory (DRAM), Fast Page Mode DRAM (FPM DRAM), Enhanced DRAM (EDRAM), Extended Data Output RAM (EDO RAM), Extended Data Output DRAM (EDO DRAM), Burst Extended Data Output DRAM (BEDO DRAM), Enhanced DRAM (EDRAM), synchronous DRAM (SDRAM), JEDEC SRAM, PC100 SDRAM, Double Data Rate SDRAM (DDR SDRAM), Enhanced SDRAM (ESDRAM), SyncLink DRAM (SLDRAM), Direct Rambus DRAM (DRDRAM), or Ferroelectric RAM (FRAM). The main memory **122** may be based on any of the above described memory chips, or any other available memory chips capable of operating as described herein. In the embodiment shown in FIG. **1B**, the processor **121** communicates with main memory **122** via a system bus **150** (described in more detail below). FIG. **1C** depicts an embodiment of a computing device **100** in which the processor communicates directly with main memory **122** via a memory port **103**. For example, in FIG. **1C** the main memory **122** may be DRDRAM.

FIG. **1C** depicts an embodiment in which the main processor **121** communicates directly with cache memory **140** via a secondary bus, sometimes referred to as a backside bus. In other embodiments, the main processor **121** communicates with cache memory **140** using the system bus **150**. Cache memory **140** typically has a faster response time than main memory **122** and is typically provided by SRAM, BSRAM, or EDRAM. In the embodiment shown in FIG. **1C**, the processor **121** communicates with various I/O devices **130** via a local system bus **150**. Various buses may be used to connect the

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central processing unit **121** to any of the I/O devices **130**, including a VESA VL bus, an ISA bus, an EISA bus, a MicroChannel Architecture (MCA) bus, a PCI bus, a PCI-X bus, a PCI-Express bus, or a NuBus. For embodiments in which the I/O device is a video display **124**, the processor **121** may use an Advanced Graphics Port (AGP) to communicate with the display **124**. FIG. **1C** depicts an embodiment of a computer **100** in which the main processor **121** communicates directly with I/O device **130b** via HYPERTRANSPORT, RAPIDIO, or INFINIBAND communications technology. FIG. **1C** also depicts an embodiment in which local busses and direct communication are mixed: the processor **121** communicates with I/O device **130a** using a local interconnect bus while communicating with I/O device **130b** directly.

A wide variety of I/O devices **130a-130n** may be present in the computing device **100**. Input devices include keyboards, mice, trackpads, trackballs, microphones, and drawing tablets. Output devices include video displays, speakers, inkjet printers, laser printers, and dye-sublimation printers. The I/O devices may be controlled by an I/O controller **123** as shown in FIG. **1B**. The I/O controller may control one or more I/O devices such as a keyboard **126** and a pointing device **127**, e.g., a mouse or optical pen. Furthermore, an I/O device may also provide storage and/or an installation medium **116** for the computing device **100**. In still other embodiments, the computing device **100** may provide USB connections (not shown) to receive handheld USB storage devices such as the USB Flash Drive line of devices manufactured by Twintech Industry, Inc. of Los Alamitos, Calif.

Referring again to FIG. **1B**, the computing device **100** may support any suitable installation device **116**, such as a floppy disk drive for receiving floppy disks such as 3.5-inch, 5.25-inch disks or ZIP disks, a CD-ROM drive, a CD-R/RW drive, a DVD-ROM drive, tape drives of various formats, USB device, hard-drive or any other device suitable for installing software and programs. The computing device **100** may further comprise a storage device, such as one or more hard disk drives or redundant arrays of independent disks, for storing an operating system and other related software, and for storing application software programs such as any program related to the client agent **120**. Optionally, any of the installation devices **116** could also be used as the storage device. Additionally, the operating system and the software can be run from a bootable medium, for example, a bootable CD, such as KNOPPIX, a bootable CD for GNU/Linux that is available as a GNU/Linux distribution from knoppix.net.

Furthermore, the computing device **100** may include a network interface **118** to interface to the network **104** through a variety of connections including, but not limited to, standard telephone lines, LAN or WAN links (e.g., 802.11, T1, T3, 56 kb, X.25, SNA, DECNET), broadband connections (e.g., ISDN, Frame Relay, ATM, Gigabit Ethernet, Ethernet-over-SONET), wireless connections, or some combination of any or all of the above. Connections can be established using a variety of communication protocols (e.g., TCP/IP, IPX, SPX, NetBIOS, Ethernet, ARCNET, SONET, SDH, Fiber Distributed Data Interface (FDDI), RS232, IEEE 802.11, IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, CDMA, GSM, WiMax and direct asynchronous connections). In one embodiment, the computing device **100** communicates with other computing devices **100'** via any type and/or form of gateway or tunneling protocol such as Secure Socket Layer (SSL) or Transport Layer Security (TLS), or the Citrix Gateway Protocol manufactured by Citrix Systems, Inc. of Ft. Lauderdale, Fla. The network interface **118** may comprise a built-in network adapter, network interface card, PCMCIA

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network card, card bus network adapter, wireless network adapter, USB network adapter, modem or any other device suitable for interfacing the computing device **100** to any type of network capable of communication and performing the operations described herein.

In some embodiments, the computing device **100** may comprise or be connected to multiple display devices **124a-124n**, which each may be of the same or different type and/or form. As such, any of the I/O devices **130a-130n** and/or the I/O controller **123** may comprise any type and/or form of suitable hardware, software, or combination of hardware and software to support, enable or provide for the connection and use of multiple display devices **124a-124n** by the computing device **100**. For example, the computing device **100** may include any type and/or form of video adapter, video card, driver, and/or library to interface, communicate, connect or otherwise use the display devices **124a-124n**. In one embodiment, a video adapter may comprise multiple connectors to interface to multiple display devices **124a-124n**. In other embodiments, the computing device **100** may include multiple video adapters, with each video adapter connected to one or more of the display devices **124a-124n**. In some embodiments, any portion of the operating system of the computing device **100** may be configured for using multiple displays **124a-124n**. In other embodiments, one or more of the display devices **124a-124n** may be provided by one or more other computing devices, such as computing devices **100a** and **100b** connected to the computing device **100**, for example, via a network. These embodiments may include any type of software designed and constructed to use another computer's display device as a second display device **124a** for the computing device **100**. One ordinarily skilled in the art will recognize and appreciate the various ways and embodiments that a computing device **100** may be configured to have multiple display devices **124a-124n**.

In further embodiments, an I/O device **130** may be a bridge between the system bus **150** and an external communication bus, such as a USB bus, an Apple Desktop Bus, an RS-232 serial connection, a SCSI bus, a FireWire bus, a FireWire 800 bus, an Ethernet bus, an AppleTalk bus, a Gigabit Ethernet bus, an Asynchronous Transfer Mode bus, a HIPPI bus, a Super HIPPI bus, a SerialPlus bus, a SCI/LAMP bus, a Fibre-Channel bus, or a Serial Attached small computer system interface bus.

A computing device **100** of the sort depicted in FIGS. **1B** and **1C** typically operates under the control of operating systems, which control scheduling of tasks and access to system resources. The computing device **100** can be running any operating system such as any of the versions of the MICROSOFT WINDOWS operating systems, the different releases of the Unix and Linux operating systems, any version of the MAC OS for Macintosh computers, any embedded operating system, any real-time operating system, any open source operating system, any proprietary operating system, any operating systems for mobile computing devices, or any other operating system capable of running on the computing device and performing the operations described herein. Typical operating systems include, but are not limited to: WINDOWS 3.x, WINDOWS 95, WINDOWS 98, WINDOWS 2000, WINDOWS NT 3.51, WINDOWS NT 4.0, WINDOWS CE, and WINDOWS XP, and WINDOWS VISTA, all of which are manufactured by Microsoft Corporation of Redmond, Wash.; MAC OS, manufactured by Apple Computer of Cupertino, Calif.; OS/2, manufactured by International Business Machines of Armonk, N.Y.; and Linux, a freely-avail-

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able operating system distributed by Caldera Corp. of Salt Lake City, Utah, or any type and/or form of a Unix operating system, among others.

The computer system **100** can be any workstation, desktop computer, laptop or notebook computer, server, handheld computer, mobile telephone or other portable telecommunication device, media playing device, a gaming system, mobile computing device, or any other type and/or form of computing, telecommunications or media device that is capable of communication and that has sufficient processor power and memory capacity to perform the operations described herein. For example, the computer system **100** may comprise a device of the IPOD family of devices manufactured by Apple Computer of Cupertino, Calif., a PLAYSTATION 2, PLAYSTATION 3, or PERSONAL PLAYSTATION PORTABLE (PSP) device manufactured by the Sony Corporation of Tokyo, Japan, a NINTENDO DS, NINTENDO GAMEBOY, NINTENDO GAMEBOY ADVANCED or NINTENDO REVOLUTION device manufactured by Nintendo Co., Ltd., of Kyoto, Japan, or an XBOX or XBOX 360 device manufactured by the Microsoft Corporation of Redmond, Wash.

In some embodiments, the computing device **100** may have different processors, operating systems, and input devices consistent with the device. For example, in one embodiment, the computing device **100** is a TREO 180, 270, 600, 650, 680, 700p, 700w, or 750 smart phone manufactured by Palm, Inc. In some of these embodiments, the TREO smart phone is operated under the control of the PalmOS operating system and includes a stylus input device as well as a five-way navigator device.

In other embodiments the computing device **100** is a mobile device, such as a JAVA-enabled cellular telephone or personal digital assistant (PDA), such as the i55sr, i58sr, i85s, i88s, i90c, i95cl, or the im1100, all of which are manufactured by Motorola Corp. of Schaumburg, Ill., the 6035 or the 7135, manufactured by Kyocera of Kyoto, Japan, or the i300 or i330, manufactured by Samsung Electronics Co., Ltd., of Seoul, Korea. In some embodiments, the computing device **100** is a mobile device manufactured by Nokia of Finland, or by Sony Ericsson Mobile Communications AB of Lund, Sweden.

In still other embodiments, the computing device **100** is a Blackberry handheld or smart phone, such as the devices manufactured by Research In Motion Limited, including the Blackberry 7100 series, 8700 series, 7700 series, 7200 series, the Blackberry 7520, or the Blackberry Pearl 8100. In yet other embodiments, the computing device **100** is a smart phone, Pocket PC, Pocket PC Phone, or other handheld mobile device supporting Microsoft Windows Mobile Software. Moreover, the computing device **100** can be any workstation, desktop computer, laptop or notebook computer, server, handheld computer, mobile telephone, any other computer, or other form of computing or telecommunications device that is capable of communication and that has sufficient processor power and memory capacity to perform the operations described herein.

In some embodiments, the computing device **100** is a digital audio player. In one of these embodiments, the computing device **100** is a digital audio player such as the Apple IPOD, IPOD Touch, IPOD NANO, and IPOD SHUFFLE lines of devices, manufactured by Apple Computer of Cupertino, Calif. In another of these embodiments, the digital audio player may function as both a portable media player and as a mass storage device. In other embodiments, the computing device **100** is a digital audio player such as the DigitalAudioPlayer Select MP3 players, manufactured by Samsung Electronics America, of Ridgefield Park, N.J., or the

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Motorola m500 or m25 Digital Audio Players, manufactured by Motorola Inc. of Schaumburg, Ill. In still other embodiments, the computing device **100** is a portable media player, such as the Zen Vision W, the Zen Vision series, the Zen Portable Media Center devices, or the Digital MP3 line of MP3 players, manufactured by Creative Technologies Ltd. In yet other embodiments, the computing device **100** is a portable media player or digital audio player supporting file formats including, but not limited to, MP3, WAV, M4A/AAC, WMA Protected AAC, AIFF, Audible audiobook, Apple Lossless audio file formats and .mov, .m4v, and .mp4 MPEG-4 (H.264/MPEG-4 AVC) video file formats.

In some embodiments, the computing device **100** comprises a combination of devices, such as a mobile phone combined with a digital audio player or portable media player. In one of these embodiments, the computing device **100** is a Motorola RAZR or Motorola ROKR line of combination digital audio players and mobile phones. In another of these embodiments, the computing device **100** is an iPhone smartphone, manufactured by Apple Computer of Cupertino, Calif.

Referring now to FIG. 2A, a block diagram depicts one embodiment of a system for displaying a plurality of resources on one or more display devices. In brief overview, the system includes a mobile computing device **102** that may communicate with one or more external display devices **202a-n**. The embodiment in FIG. 2A shows a mobile computing device **102** with a native display **201**, although devices without native displays may be used in other embodiments. The mobile computing device **102** executes a plurality of resources **204a-n** (collectively, **204**). The window management system **206** and virtual graphics driver **208** manage the locations and sizes of the display of output data associated with each of the plurality of resources in a user-configurable display layout. In many embodiments, the mobile computing device **102** transmits the output data associated with each of the plurality of resources **204** to an external display device **202**. In some of these embodiments, the mobile computing device **102** transmits the output data upon establishing a connection with the external display device **202**. In various embodiments, the mobile computing device **102** transmits the output data associated with each of the plurality of resources **204** to the device's native display **201**. In many embodiments, the mobile computing device **102** transmits the output data associated with certain of the plurality of resources **204** to the native display **201** and transmits the output data associated with other of the plurality of resources **204** to the external display devices **202a-n**.

Referring now to FIG. 2A, and in greater detail, a mobile computing device **102** executes a plurality of resources **204**. In one embodiment, the mobile computing device **102** is a client **102** as described above in connection with FIGS. 1A-1C. In another embodiment, the mobile computing device **102** displays the output data associated with a resource **204a** in a plurality of resources **204a-n** executed by the mobile computing device **102**. In some embodiments, the mobile computing device **102** displays the output data associated with each of the plurality of resources **204**.

In one embodiment, a resource in the plurality of resources **204** may include, without limitation, a data file, an executable file, configuration files, an application, a desktop environment (which may itself include a plurality of applications for execution by the user), a computing environment image (such as a virtual machine image), and/or operating system software or other applications needed to execute a computing environment image.

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In one embodiment, the mobile computing device **102** includes a window management service **206** allowing an external display device **202** to display the output data associated with each of a plurality of resources **204** executed on the mobile computing device **102**. In still another embodiment, the window management service **206** allows multiple resources running on the mobile computing device **102** to be viewed on an external display device **202** or the native display **201** at substantially the same time, as opposed to allowing the output of one resource **204** to be viewed exclusively on the native display **201** or external display device **202**. In yet another embodiment, the window management service **206**, in conjunction with a virtual graphics driver **208**, manages the display layout of the windows displayed on the external display device **202** and the native display **201**. In some embodiments, the virtual graphics driver **208** is a driver-level component that manages a virtual screen frame buffer storing output data that will be displayed by the native display **201** on the mobile computing device **102** or an external display device **202**. In one of these embodiments, the window management service **206**, in conjunction with the virtual graphics driver **208**, manages the boundaries and size of a screen space used to display output data and on which display device the output data is displayed.

In some embodiments, an external display device **202** receives output data associated with each of the plurality of resources **204** and displays the output data in a user-configurable display layout. In one embodiment, the external display device **202** includes a dock to which the mobile computing device **102** connects. In another embodiment, the external display device **202** includes a receiver for communicating with the mobile computing device **102** wirelessly, for example, via BLUETOOTH, Wi-Fi or other networking protocols, as described above in connection with FIGS. 1A-1C. In still another embodiment, the external display device **202** is a display device **124** as described above in connection with FIG. 1B-1C.

Referring now to FIG. 2B, a block diagram depicts one embodiment of a system for mapping the display of one or more resources **204** of the mobile computing device **102** on one or more display devices **201** and/or **202**. In various embodiments, the window management service **206** manages a virtual screen space **210**. The virtual screen space **210** may map to the native display **201** and one or more external display devices **202**. The window management service **206** may position output data associated with the user interfaces of one or more resources **204** on the virtual screen space **210** to specify where each user interface will be displayed. In some embodiments, the window management service **206** positions the output data according to a user preference. In additional embodiments, the window management service **206** positions the output data according to a policy. In various embodiments, the window management service **206** positions the output data based on the resource **204** associated with the output data.

The window management service **206** communicates with the virtual graphics driver **208** to transmit output data associated with user interfaces of resources **204** to the native display **201** and one or more external display devices **202**. In some embodiments, the window management service **206** may transmit output data and associated coordinates from the virtual screen space **210** to the virtual graphics driver **208**. In various embodiments, the virtual graphics driver **208** stores the output data in a virtual screen frame buffer. In many embodiments, the virtual graphics driver **208** transmits the entries in the virtual screen frame buffer to the native display **201** and external display devices **202**. In many embodiments,

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the virtual graphics driver **208** transmits an entry in the virtual screen frame buffer to a native display **201** or an external display device **202** based on the position of the entry in the frame buffer.

Referring now to FIG. 2C, a screen shot depicts one embodiment of a user-configurable display layout in which the external display device **202** displays the output data of the resources **204**. In this embodiment, the output data of the resources **204** is displayed in a grid display layout. The grid display layout may include one or more cells in an arrangement. A cell may display output data associated with a resource. In some embodiments, more than one cell displays output data associated with the same resource.

In some embodiments, the cells are uniformly sized, whereas in other embodiments, the cells have different sizes. The cells may be arranged in any configuration. In some embodiments, the cells may be arranged in rows, columns, or both. A cell may have a descriptor associated with the cell's position in the grid. The descriptor may indicate the position of a cell within a row. In the embodiment depicted in FIG. 2C, the cell for resource **204a** may have the descriptor "1-1," the cell for resource **204b** may have the descriptor "1-2," the cell for resource **204c** may have the descriptor "1-3," the cell for resource **204d** may have the descriptor "2-1," and the cell for resource **204d** may have the descriptor "2-2." In other embodiments, the cells may be numbered, e.g., "Cell 1," "Cell 2," etc. However, any system of choosing descriptors known to those of ordinary skill in the art may be used.

In various embodiments, the window management service **206** configures a grid display layout according to the resources **204** being displayed on the native display **201** or the external display device **202**. In some embodiments, the service **206** configures a grid display layout according to the number of resources **204** being displayed. In other embodiments, the service **206** configures a grid display layout according to the size or amount of content in the user interfaces of the resources **204**. For example, if an external display device **202** will display four resources with comparable amounts of content, the window management service **206** may configure a grid display layout with four uniform cells. In another example, if an external display device **202** will display four resources and one resource includes three times as much content as the others, the window management service **206** may configure a grid display layout with three uniform cells in a first row and a single cell in a second row. The single cell in the second row may be three times as wide as the cells in the first row. In various embodiments, the window management service **206** may configure a grid display layout to reserve a cell for displaying information about the resources being displayed, such as a menu of the resources. In many embodiments, the window management service **206** may configure a grid display layout to reserve a cell for allowing a user to configure the grid display layout.

Referring now to FIG. 2D, a screen shot depicts one embodiment of a user-configurable display layout providing a dynamic display layout in which the external display device **202** displays the output data associated with the plurality of resources **204**. In this embodiment, windows on the external display device **202** that display output data for resources **204** may be dynamically positioned and sized. The window management service **206** may position a user interface for a resource at a default position and with a default size chosen according to a policy, the resource **204**, or any other method. The window management service **206** may order overlapping user interfaces such that higher-order user interfaces obscure lower-order user interfaces. The window management service **206** may transmit output data to the virtual graphics

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driver **208** reflecting the obfuscation. The user may re-position or re-size a window by, for example, clicking and dragging the window or a window edge. In these embodiments, the virtual graphics driver **208** may detect the user's change to the window, and transmit information about the user's change to the window management service **206**. The window management service **206** may process the change and transmit updated output data to the virtual graphics driver **208**. In some embodiments, the user moves the user interface for a resource **204** to any location on a native display **201** or external display device **202**. In some embodiments, the user moves the user interface for a resource **204** to a different display device. In some embodiments, the updated output data indicates that one user interface's size has been increased or location has been adjusted to obscure another user interface. In other embodiments, the updated output data indicates that one user interface's size has been decreased or location has been adjusted such that more of another user interface shall be visible.

Referring now to FIG. 3A, a block diagram depicts one embodiment of virtual screen spaces **210** provided by a mobile computing device attached to one or more external display devices. As shown in FIG. 3A, the mobile computing device **102** includes a virtual graphics driver **208** and a virtual screen **210**. The virtual screen **210** includes a plurality of virtual screen spaces **310** and **312a-n**. Virtual screen space **310** may be a native display screen space for the native display **201** on the mobile computing device **102**. The other virtual screen spaces **312a-n** may be extended screen spaces that correspond to the displays of external display devices **202**. The window management service **206** and virtual graphics driver **208** manage the virtual screen **210**. In one embodiment, the virtual graphics driver **208** uses a virtual screen frame buffer to manage the mobile computing device's native display **201** and change the native display's **201** screen resolution. In another embodiment, the virtual graphics driver **208** uses a virtual screen frame buffer to manage an extended screen space **312** and to change a resolution of the extended screen **312**.

In some embodiments, the virtual graphics driver **208** allocates and manages a plurality of virtual screen spaces **310**, **312a-n** and virtual screen frame buffers. In some of these embodiments, each virtual screen space and virtual screen frame buffer has a resolution independent of the other screen spaces and frame buffers. In one of these embodiments, output data associated with each of the plurality of resources **204** can reside within any of the virtual screen spaces **310**, **312a-n**. In another of these embodiments, each of the extended screen spaces **312a-n** is associated with at least one external display device **202**, depending on the capabilities of the device.

In various embodiments, the window management service **206** and the virtual graphics driver **208** allocate and manage the display, on a plurality of external display devices **202**, of output data associated with a plurality of resources. In one of these embodiments, for example, output data associated with a resource **204a** displays on a mobile computing device **102**, output data associated with a resource **204b** displays on one external display device **202a**, and output data associated with a resource **204c** display on another external display device **202b**. In another of these embodiments, the window management device **206** identifies one of the external display devices **202** for displaying output data generated by a resource **204a** based upon a type of the resource **204a**. For example, the window management service **206** may determine that a type of resource rendering a video may display on a television screen, while a type of resource rendering a word processing application may render on a display of a laptop computer.

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Referring now to FIG. 3B, a block diagram depicts one embodiment of a mobile computing device **102** providing a virtual screen **210** with virtual screen spaces **310**, **312a-n** of varying resolutions. In this embodiment, the virtual screen **210** includes a native display screen space **310** corresponding to the native display **201** of the mobile computing device **102** with a resolution of 320 pixels×240 pixels. The virtual screen **210** also includes an extended screen **312a** corresponding to the display of an external display device **202** with a resolution of 1024 pixels×768 pixels, an extended screen **312n-1** corresponding to the display of an external display device **202** with a resolution of 800 pixels×600 pixels, and an extended screen **312n** corresponding to the display of an external display device **202** with a resolution of 640 pixels×480 pixels. In many embodiments, the virtual screen **210** may include a native display screen space **310** and any number of extended screens **312** of any resolution. The entire virtual screen space **210** may be mapped into a single virtual screen frame buffer, although embodiments that map into multiple buffers may be used.

Referring now to FIG. 3C, a block diagram depicts one embodiment of a logical representation of a plurality of virtual screen spaces managed by a virtual graphics driver. In this embodiment, the virtual graphics driver **208** manages multiple virtual screen spaces with different resolutions in a virtual screen frame buffer. In this embodiment, the native display **201** of the mobile computing device is the primary display and the external display device **202**, corresponding to the extended screen **312a**, is a secondary display. In various embodiments, output data associated with resources **204** on the native display screen space **310** will be displayed on the native display **201** and output data associated with resources **204** on the extended screen space **312a** will be displayed on the external display device **202** associated with the extended screen spaces **312a**.

Referring now to FIG. 4A, a block diagram depicts one embodiment of a graphical user interface for customizing a dynamic display layout. In general overview, the user selects a screen space and sets parameters to configure the space. In this embodiment, the user selects a screen space from interface element **401**. In various embodiments, the user may select a screen space by selecting a tab, icon, button, or radio button associated with a screen space, selecting a screen space from a drop-down menu, typing the name of a screen space into a text box, or any other methods known to persons of ordinary skill in the art. In further embodiments, the user may create a new screen space. In this embodiment, the user may create a new screen space by selecting the “Add New Display” button **403**, and an interface element **401** corresponding to the new screen space may be created and added to the graphical user interface. The user may name the new screen space, assign an external display device **202** corresponding to the space, and configure the screen space according to the methods described below.

In various embodiments, the graphical user interface may include interface elements the user manipulates to set parameters for the space. In this embodiment, the graphical user interface includes interface elements **402** and **404** for setting the resolution and mode of the screen space, respectively, and in many embodiments, the graphical user interface may include interface elements for setting any other parameters such as z-order or default position. In this embodiment, the user sets the resolution by selecting a radio button from an interface element **402** corresponding to a predetermined resolution or selecting a radio button to customize the width and height of the screen’s resolution. In other embodiments, the user may set the resolution by adjusting a slider to a desired

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resolution, selecting a thumbnail from a group of thumbnails representing displays of the screen space at different resolutions, or clicking and dragging a boundary of an image representing the screen space to change the resolution. In this embodiment, the user sets the mode by selecting a radio button from an interface element **404** indicating whether the user wishes the screen space to be a primary display, an extended display, a display that mirrors the primary display, or a disabled display, although any other modes may be used. In other embodiments, the user may set the mode by selecting an icon representing the mode, selecting the mode from a drop-down menu, or any other method.

Referring now to FIG. 4B, a block diagram depicts one embodiment of a graphical user interface for customizing a grid display layout. The user may select the screen space to customize according to any of the methods described in FIG. 4A. In many embodiments, the graphical user interface allows users to configure the number, size, and position of cells within a grid in which the output data for each of the plurality of resources **204** is displayed. In one embodiment, the user may add cells to the grid by selecting the user interface element **406**, an “Add Cell” button. Each time the user selects the “Add Cell” button, a new numbered cell appears in the grid, and the user may delete a cell by selecting the cell and the user interface element **407**, a “Delete Cell” button. In many embodiments, the user may configure the position, resolution, or both of each cell. In some embodiments, the user may configure the position by dragging and dropping the cell to the desired location. In other embodiments, the user may configure the position by entering a numerical value corresponding to the desired position for the cell. For example, the user may select a cell and input the position “2-1” to indicate the cell should appear in the second row and first column of the grid. In all of these embodiments, the remaining cells may automatically readjust their positions in response to the user’s selection of a position for the new cell.

In various embodiments, the user may configure the resolution of each cell. In some embodiments, the user configures the resolution by dragging and dropping a boundary of a cell to the desired size. In other embodiments, the user configures the resolution by selecting from a group of resolutions. The embodiment shown in FIG. 4B depicts a user interface element **408** in the form of radio buttons corresponding to a group of resolutions, including a radio button that permits the user to customize the resolution of the cell. In other embodiments, a user may select a resolution by selecting a check box, clicking a button, choosing a resolution from a drop-down menu, or any other known method of inputting information.

In many embodiments, a user may configure the grid display layout prior to the display of output data by the external display device **202**. For example, the user may choose a setting associated with a preferred cell position and resolution for each resource in the plurality of resources **204** in a user profile. Upon execution of the resource, the window management service **206** may consult the user profile to determine how to display the user interface of the resource **204**. In other embodiments, the user may configure the grid display layout during the display of output data by the external display device **202**. For example, upon execution of a resource **204** by the mobile computing device **102**, the user may choose or modify a setting associated with a preferred cell position and resolution for the resource **204**.

In various embodiments, a user may associate output data for a resource **204** with a cell in the grid display layout. In some embodiments, the user may select a cell on the grid display layout and associate a resource with the cell such that output data of the resource appears in the selected cell. In

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some embodiments, the user may associate a plurality of resources with the same cell and prioritize the resources to determine which output data will be displayed in the cell if more than one of the associated resources are being executed. In other embodiments, the user may associate a resource with a cell by dragging the output data generated by the resource to the cell in the grid display layout. The window management service **206** may store the association between the cell and the resource **204**.

Referring now to FIG. 4C, a screen shot depicts one embodiment of a customized grid display layout. In this embodiment, the grid display layout includes output data for a calendar **420**, file explorer **422**, and e-mail **424** corresponding to cells **1**, **2**, and **3** in the grid layout of FIG. 4B. In this embodiment, no resources have been associated with the interface element **430** corresponding to cell **4**, an empty cell. In various embodiments, empty cells include a user interface element **430** for selecting a resource whose output data should display in the cell. In some embodiments, the user interface element **430** enumerates at least one resource **204** whose output data is available for display on the external display device **202**. In still another embodiment, upon selection of a resource **204** by a user via the user interface element **430**, the window management system **206** receives an identification of the selected resource **204**. The window management system **206** may associate the selected resource with the cell corresponding to the user interface element **430**. In still even another embodiment, the window management system **206**, in communication with the virtual graphics driver **208**, manages an association between the selected resource and the cell corresponding to the user interface element **430** to output data associated with the resource to the cell in the customizable grid display layout.

Referring now to FIG. 4D, a screen shot depicts one embodiment of a dynamic display layout provided by a mobile computing device **102** displaying the output data generated by each of a plurality of resources **204** on the native display **201** of the mobile computing device **102**. In this embodiment, the output data for all the resources may be displayed on the native display **201** because the mobile computing device **102** is not attached to any external display devices. In this embodiment, the dynamic layout includes four windows **440**, **442**, **444**, and **446** that contain output data generated by four resources executing on the mobile computing device **102**. In various embodiments, a window **440** for a resource **204** may be dynamically displayed on the native display **201** of the mobile computing device **102** when the resource **204** is first executed. In many embodiments, the user may dynamically resize the window **440** by, for example, dragging and dropping a boundary of a window **440** to the desired location. In further embodiments, the user may move the window **440** to any position on the native display **201**. In some embodiments, the user may move the window **440** to an external display device **202** connected to the mobile computing device **102**. In some embodiments, the user may minimize the window **440** on the native display **201** of the mobile computing device **102**. In many embodiments, the user may change focus from a window displaying output data associated with one resource **204a** to a window displaying output data associated with another resource **204b**. The user may change focus by selecting the window containing output data for the desired resource **204b**. When the user changes the focus to resource **204b**, the output data generated by resource **204b** may obscure output data generated by other resources **204** executing on the mobile computing device **102**. In still another embodiment, the windows **440-448** can be adjusted in any manner and/or form on any display, either the native

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display **201** or external display devices **202**, as apparent to one of ordinary skill in the art.

Referring now to FIG. 4E, a flow diagram depicts one embodiment of the steps taken in a method for displaying, by an external display device **202**, output data generated by a resource **204** executing on a mobile computing device **102**. In brief overview, the method includes the step of executing, by a mobile computing device **102**, a plurality of resources **204** (step **402**). The method includes the step of displaying, by the external display device **202**, in a user-configurable display layout, the received output data associated with each of the plurality of resources **204** (step **404**).

Referring still to FIG. 4E, and in greater detail, a mobile computing device **102** executes a plurality of resources **204** (step **402**). In one embodiment, the mobile computing device **102** substantially simultaneously executes the plurality of resources **204**. In another embodiment, the mobile computing device **102** substantially simultaneously executes a subset of the plurality of resources **204**.

The external display device displays, in a user-configurable grid display layout, the received output data generated by each of the plurality of resources **204** (step **404**). As described above in connection with FIGS. 2A-2D, in various embodiments, the mobile computing device **102** determines for each of the plurality of resources **204** whether to transfer output data associated with the resource **204** to the external display device **202**.

In some embodiments, a window management service **206** manages the size, position, resolution, or any other characteristic of a resource **204** in the virtual screen space **210**. In one embodiment, a window management service **206** executing on the mobile computing device **102**, and in communication with a virtual graphics driver **208**, identifies the resources **204** whose output data the external display device **202** should display. In another embodiment, the window management service **206** receives, from the virtual graphics driver **208**, an identification of an external display device **202** attached to the mobile computing device **102**. In still another embodiment, the window management service **206** evaluates each of the plurality of resources **204** to determine whether the external display device **202** should display the output data generated by each of the plurality of resources **204**. In still even another embodiment, the window management service **206** evaluates a setting associated with each of the plurality of resources **204** to determine whether the external display device **202** should display the output data generated by each of the plurality of resources **204**. In yet another embodiment, the window management service **206** evaluates a user-specified preference setting associated with each of the plurality of resources **204** to determine whether the external display device **202** should display the output data generated by each of the plurality of resources **204**.

In one embodiment, the window management service **206** instructs the virtual graphics driver **208** to forward output data generated by a resource **204** executing on the mobile computing device to the external display device **202** for display. In another embodiment, the window management service **206** instructs the virtual graphics driver **208** to forward the output data generated by the resource **204** to the external display device responsive to determining that a setting associated with the resource **204** indicates that the output data generated by the resource **204** should be displayed on the external display device **202**. In still another embodiment, a plurality of settings are associated with the resource **204**, each of the plurality of settings indicating whether the output data generated by the resource **204** should be displayed on each of a plurality of types of external display device **202**; for example,

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a first setting associated with the resource **204** may indicate that the generated output data should be displayed on the external display device **202** if the external display device **202** is a television screen and a second setting associated with the resource **204a** may indicate that the generated output data should not be displayed on the external display device **202** if the external display device **202** has a display below a certain size and/or resolution.

In one embodiment, the window management service **206** instructs the virtual graphics driver **208** to have the output data for a resource **204** displayed on the external display device **202** in a grid display layout. In another embodiment, the window management service **206** instructs the virtual graphics driver **208** to have the output data for a resource **204** displayed on the external display device **202** in a dynamic display layout. In still another embodiment, the window management service **206** evaluates a setting associated with each of the plurality of resources **204** to identify a display layout according to which the external display device **202** should display the output data generated by each of the plurality of resources **204**. In yet another embodiment, the window management service **206** evaluates a user-specified preference setting associated with each of the plurality of resources **204** to identify a display layout according to which the external display device **202** should display the output data generated by each of the plurality of resources **204**; for example, and in some embodiments, a user specifies a subset of the plurality of resources **204** for which the external display device **202** should display output data.

In one embodiment, the virtual graphics driver **208** forwards output data generated by a resource **204** executing on the mobile computing device to the external display device **202** for display. In another embodiment, the virtual graphics driver **208** instructs an operating system of the mobile computing device **102** to forward output data generated by a resource **204** executing on the mobile computing device to the external display device **202** for display. In still another embodiment, the virtual graphics driver **208** forwards an identification of a display layout to the external display device **202**. In yet another embodiment, the virtual graphics driver **208** instructs an operating system of the mobile computing device **102** to forward an identification of a display layout to the external display device **202**.

Referring now to FIG. 5A, a block diagram depicts one embodiment of a system for displaying, by an external display device **202**, a second user interface for a resource **204** distinct from a first user interface for the resource **204** displayed by the mobile computing device **102** that is executing the resource **204**. The system includes a window management service **206**, a virtual graphics driver **208**, and resources **204** that may provide more than one user interfaces **502a-n**. In some embodiments, the resource **204** may provide a user interface **502a** optimized for the native display **201** on the mobile computing device **102**. In additional embodiments, the resource **204** may provide a user interface **504b** optimized for display on the external display device **202**. In further embodiments, the resource **204** may provide user interfaces **502a-n** optimized for display on different external display devices **202**. In various embodiments, the window management service **206** provides functionality to allow resources to dynamically change user interfaces **502** to adapt to the external display device **202** that will display output data generated by the resource. In some embodiments, the window management service **206** indicates to a resource **204** the properties of the external display device **202** that will display the resource's output data. In response, the resource **204** provides a user interface **502b-n** appropriate for the properties of the

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external display device **202**, which may differ from the user interface **502a** provided to the native display **201** of the mobile computing device. In various embodiments, the mobile computing device **101** may execute a plurality of resources **204**, and each resource may provide a plurality of user interfaces **502** optimized for display on the native display **201** of a mobile computing device **102** or on an external display device **202**.

Referring now to FIG. 5B, a block diagram depicts one embodiment of a system for mapping a first user interface **502a** on the native display **201** of the mobile computing device **102** to a second user interface **502b** on one or more external display devices **202**. In one embodiment, the virtual graphics driver **208** maps all the screen spaces **210a-n** from the display of the mobile computing device **102** and/or the external display devices **202** into one virtual screen space **210**. In another embodiment, the virtual graphics driver **208** communicates the coordinates related to the virtual screen space **210** to the window management service **206**. In still another embodiment, the window management service **206** positions user interfaces of one or more resources **204** onto the virtual screen space **210**. In yet another embodiment, the window management services **206** uses information provided by the virtual graphics driver **208** to position the user interfaces on an external display device **202**. In one embodiment, the user interface **502b** for the resource **204** displayed by an external display device **202** is substantially same as the user interface **502a** displayed on the native display **201**. In another embodiment, the user interface **502b** displayed by an external display device **202** is distinct from the user interface **502a** displayed on the native display **201**. In various embodiments, the user interface for any resource **204** displayed on an external display device **202** is distinct from the user interface **510** displayed on a different external display device **202**.

Referring now to FIG. 5C, a screen shot depicts one embodiment of a system for displaying, by an external display device **202**, a second user interface **502b** for a resource **204** distinct from a first user interface **502a** for the resource **204** displayed by a mobile computing device **102** that is executing the resource **204**. As depicted in FIG. 5C, and in many embodiments, a resource **204** may generate a plurality of user interfaces **502a** and **502b**, each of which may be optimized for use with a different type of display device. In one embodiment, a first user interface **502a** of the plurality of user interfaces may be optimized for use with the native display **201** of a mobile computing device **102**. In another embodiment, the second user interface **502b** of the plurality of user interfaces may be optimized for use with an external display device **202**. In various embodiments, the first user interface **502a** may be displayed on the native display **201** of the mobile computing device **102** until the mobile computing device **102** is attached to an external display device **202**. When the mobile computing device **102** is attached, the second user interface **502b** may be displayed on the external display device **102**. In some embodiments, the mobile computing device **102** may cease to display the first user interface **502a** upon attachment, and in other embodiments, the mobile computing device **102** may continue to display the first user interface **502a** as the external display device **102** displays the second user interface **502b**.

Referring now to FIG. 6, a flow diagram depicts an embodiment of the steps taken in a method for displaying, by an external display device, a first user interface to an application distinct from a second user interface to the application displayed by a mobile computing device executing the application. In brief overview, the method includes the step of generating, by a resource executing on a mobile computing

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device, a first user interface for display on the mobile computing device (step 610). The method includes the step of receiving, by the resource, from a window management service, an identification of an external display device (step 612). The method includes the step of generating, by the resource, a second user interface for display on the external display device, responsive to receiving the identification of the external display device (step 614).

Referring now to FIG. 6, and in greater detail, a resource executing on a mobile computing device generates a first user interface for display on the mobile computing device (step 610). In one embodiment, the resource 204 generates a user interface 502a optimized for use with the mobile computing device 102. The resource receives, from a window management service, an identification of an external display device (step 612). In one embodiment, the resource receives the identification of the external display device 202 via a virtual graphics driver 208.

In response to receiving the identification of the external display device 202, the resource generates a second user interface 502b for display on the external display device (step 614). In one embodiment, the window management service 206 receives an identification of an external display device 202 to which the mobile computing device 102 has attached. In some embodiments, the window management service 206 transmits, to the resource, an application programming interface (API) call indicating to the resource that the external display device 202 is available. The window management service 206 may inform the resource 204 executing on the mobile computing device of the identification of the attached external display device 202. In some embodiments, the window management service 206 indicates to the resource 204 that the external display device 202 has a display with a larger resolution or size than the native display 201 on the mobile computing device 102. In further embodiments, the window management service 206 allows the resource to change its user interface to an interface more optimized for use with the external display device 202.

In one embodiment, the window management service receives, from the resource, an identification of a user interface associated with the attached external display device. In some embodiments, the window management service 206 receives the identification via a virtual graphics driver 208. In other embodiments, the window management service 206 forwards the identification to the virtual graphics driver 208.

In one of these embodiments, the window management service 206 receives, from the resource, a user interface associated with the attached external display device 202. In another embodiment, when a user interface associated with the attached external display device is not available, the window management service 206 receives, from the resource, a default user interface. In still another embodiment, the window management service 206 receives from the resource a communication that a user interface associated with the attached external display device 202 is not available.

In one embodiment, the resource 204 generates a user interface 502b optimized for use with an external display device 202 to which the mobile computing device 102 is attached. In another embodiment, the resource 204 instructs an operating system on the mobile computing device 102 to display one of a plurality of user interfaces selected in response to receiving an identification of the external display device 202 upon which the user interface will be displayed. In still another embodiment, the resource 204 instructs the window management system 206 on the mobile computing device 102 to display one of the plurality of user interfaces selected responsive to receiving an identification of the external display device 202 upon which the user interface will be displayed.

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In some embodiments, the window management system 206 transmits, to the external display device 202, an identification of a user interface 504 with an instruction to display the user interface 504. In other embodiments, the window management system 206 transmits, to a virtual graphics driver 208, an identification of a user interface 504 with an instruction to display the user interface 502b on the external display device 202.

Referring now to FIG. 7A, a block diagram depicts one embodiment of a system for executing and displaying a plurality of resources 204a-204n (204 in general) on a client 102b. In one embodiment, the system includes a client 102a, which is a mobile computing device, in connection with another client 102b. In one embodiment, the client 102b includes a dock to which the mobile computing device 102a attaches. In another embodiment, the client 102b includes a receiver for communicating with the mobile computing device 102a wirelessly, for example, via BLUETOOTH, Wi-Fi or other networking protocols, as described above in connection with FIGS. 1A-1C. In still another embodiment, the client 102b includes an external display 124 as described above in connection with FIG. 1B-1C.

In one embodiment, one or more resources 204 execute on the mobile computing device 102a. In another embodiment, the mobile computing device 102a accesses hardware and/or software components of the client 102b to execute the resources 204. In still another embodiment, a version of a resource 204 is executed on the client 102b. In one embodiment, the version of the resource 204 on the client 102b can be a local copy of the resource 204 installed on the client 102b. In another embodiment, the version on the client 102b can offer more functionalities of the resource 204 than available on the mobile computing device 102a. In still another embodiment, the version on the client 102b can be another resource 204b producing the same output data as the resource 204 executing on the mobile computing device 102a. In yet another embodiment, the mobile computing device 102a and the client 102b share hardware and software resources to execute one or more resources 204.

Execution of the resource 204 may be transferred to the client 102b in many ways. In one embodiment, the execution of the resource 204 is terminated on the mobile computing device 102a and the version of the resource 204 on the client 102b is started. In another embodiment, information and/or data values related to the state of execution of the resource 204 on the mobile computing device 102a is transferred to the client 102b. In still another embodiment, no information and/or data values related to the state of execution of the resource 204 on the mobile computing device 102a is transferred to the client 102b. In such an embodiment, recent updates are not transferred to the client 102b when the execution is transferred from the mobile computing device 102a to the client 102b. In yet another embodiment, the resource 204 is transferred to the client 102b when the execution is transferred from the mobile computing device 102a to the client 102b. In one embodiment, information and/or data values related to the state of execution is also transferred when the resource 204 is transferred to the client 102b.

In some embodiments, the client 102b includes an operational or performance characteristic not provided by the mobile computing device 102a. In one of these embodiments, the client 102b has a more powerful processor and/or larger memory than the processor and memory of the mobile computing device 102a. In another of these embodiments, the client 102b provides an I/O device, display device, installation device, or other peripherals, such as a keyboard or printer

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not available to the mobile computing device **102a**. In still another of these embodiments, the client **102b** may provide a feature, a resource, or peripheral desired to be used by the user of the mobile computing device **102a**. For example, the user may want to access a file or an application provided on a remote machine available via a connection across a network. In yet another of these embodiments, the client **102b** provides access to machines on a network **104**, such as those in machine farm **38**, not available to the mobile computing device **102a**, or to a user of the mobile computing device **102a**.

In one embodiment, one or more resources **204** may execute in a virtual machine on the mobile computing device **102a**. In another embodiment, a virtual machine executing on the mobile computing device **102a** provides access to a computing environment based at a remote location. In still another embodiment, an application program stored in the mobile computing device **102a** executes to access data associated with the computing environment provided on the mobile computing device **102a**. In another embodiment, the mobile computing device **102a** executes virtualization software, at least a portion of which is stored on the mobile computing device **102a**. In still another embodiment, the mobile computing device **102a** provides access to a computing environment by executing an operating system with access to one or more applications stored on the mobile computing device **102a**, the operating system and the one or more applications having access to user data stored in the mobile computing device **102a**.

In one embodiment, the mobile computing device **102a** executes a virtual machine, responsive to data stored in the mobile computing device **102a**. In another embodiment, the mobile computing device executes a virtual machine responsive to a policy stored in the mobile computing device **102a**. In still another embodiment, the mobile computing device **102a** executes a virtual machine that provides access to a requested resource or computing environment, the virtual machine executed responsive to a virtual machine image stored in the mobile computing device **102a**. In yet another embodiment, the mobile computing device **102a** transfers execution of the virtual machine to the client **102b**.

In another embodiment, the client **102b** connects to the mobile computing device **102a**, executes a virtual machine, and provides access to a computing environment responsive to data stored in the mobile computing device **102a**. In one embodiment, the client **102b** may mount the storage device of the mobile computing device **102a** as a removable hard drive or storage element **128** of the client **102b**. In some embodiments, the mobile computing device **102a** may be a plug and play device (PnP) of the client **102b**, such that a PnP protocol such as that manufactured by Microsoft Corporation of Redmond, Wash., is used between the mobile computing device **102a** and client **102b**, such as via I/O devices **130a-130n** or a network interface **118**.

In one embodiment, the client **102b** provides access to a computing environment based on a portable computing environment provided in the mobile computing device **102a**. The client **102b** executes a virtual machine and a virtualization layer to execute the computing environment based on a virtualization software, virtual machine image, or user data. In some embodiments, the client **102b** includes a transceiver for accessing data stored in the mobile computing device **102a**.

In some embodiments, a loading mechanism on the mobile computing device **102a** actuates the establishment of the computing environment on the client **102b** based on the portable computing environment stored in the mobile computing device **102a**. In other embodiments, the loading mechanism

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of the client **102b** actuates the establishment of the computing environment. In yet another embodiment, a loading mechanism on the mobile computing device **102a** works in conjunction with the loading mechanism of the client **102b** to establish the computing environment.

Referring now to FIG. 7B, a block diagram depicts one embodiment of a system for executing resources **204** on a remote server **106** and displaying output data on a client computing device **102b**. In one embodiment, the system includes the mobile computing device **102a**, a client **102b** and a server **106**. The mobile computing device **102a** may be attached or connected to the client **102b** in a plurality of possible ways as described with reference to FIG. 7A.

In one embodiment, the client **102b** connects to a remote server **106** to request execution of a resource **204** by the server **106**. In some embodiments, the server **106** may have an operational or performance characteristic not present in the client **102b**. In another embodiment, the server **106** has more powerful hardware and/or software resources not available to the client **102b**. In still another embodiment, the server **106** provides access to machines on a network **104**, such as those in machine farm **38**, not directly available to the client **102b**.

In one embodiment, one or more resources **204** execute on the client **102b**. In another embodiment, the one or more resources **204** may include an application program to establish a remote connection with the server **106**. The client **102b** may execute, operate or otherwise provide the application, which can be any type and/or form of software, program, or executable instructions such as any type and/or form of web browser, web-based client, client-server application, a thin-client computing client, an ActiveX control, or a Java applet, or any other type and/or form of executable instructions capable of executing on the client **102**. In some embodiments, the application may be a server-based application executed on behalf of the client **102** on a server **106**. In one embodiment, the server **106** may communicate with the client **102** using a presentation layer protocol, such as the Independent Computing Architecture (ICA) protocol manufactured by Citrix Systems, Inc. of Ft. Lauderdale, Fla. or the Remote Desktop Protocol (RDP) manufactured by the Microsoft Corporation of Redmond, Wash.

In one embodiment, one or more resources **204** may execute in a virtual machine on the client **102b** as described above in connection to FIG. 7A. In another embodiment, the server **106** connects to the client **102b**, executes a virtual machine, and provides access to a computing environment. In one embodiment, the server **106** may transmit the virtual machine image to the client **102b**. In another embodiment, the server **106** transmits output data generated by the virtual machine image executed on the server **106** to the client **102b**. In still another embodiment, the virtual machine image includes a version of each of the plurality of resources **204** of the mobile computing device **102a**.

Output data from the execution of the resources **204** are displayed in one or more ways. In one embodiment, the output data generated by an execution of a resource **204a** on the server **106** is displayed on the mobile computing device **102a**. In another embodiment, the output data generated by an execution of a resource **204** on the server **106** is displayed on the client **102b**. In still another embodiment, the output data from the server **106** is displayed on the client **102b** as a part of a computing environment. In yet another embodiment, a resource **204** is executed locally on the mobile computing device **102a** and displayed on the client **102b**. In some embodiments, output data is simultaneously displayed in the mobile computing device **102a** and the client **102b**.

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Referring now to FIG. 8A, a block diagram depicts one embodiment of a system for executing resources for a mobile computing device remotely on a server and displaying output data generated by the resources on the mobile computing device, the client, or both. In one embodiment, the system includes a mobile computing device **102a** in communication with a client **102b** over a connection **104**. The system also includes a server **106** communicating with the mobile computing device **102a** over a connection **104'** and the client **102b** over a connection **104''**.

In one embodiment, one or more resources **204** executes on the mobile computing device **102a**. In another embodiment, the one or more resources **204** may include an application program to establish a connection **104** with the client **102b** and/or a connection **104'** with the server **106**. In one embodiment, the mobile computing device **102a** or the client **102b** may execute, operate or otherwise provide the application, which can be any type and/or form of software, program, or executable instructions such as any type and/or form of web browser, web-based client, client-server application, a thin-client computing client, an ActiveX control, or a Java applet, or any other type and/or form of executable instructions capable of executing on the mobile computing device **102**. In some embodiments, the application may be a server-based or a remote-based application executed on behalf of the mobile computing device **102a** or the client **102b** on a server **106**. In one embodiment, the server **106** may communicate with the mobile computing device **102a** or the client **102b** using any presentation layer protocol, such as the Independent Computing Architecture (ICA) protocol manufactured by Citrix Systems, Inc. of Ft. Lauderdale, Fla. or the Remote Desktop Protocol (RDP) manufactured by the Microsoft Corporation of Redmond, Wash.

In one embodiment, one or more resources **204** may execute in a virtual machine on the mobile computing device **102a** as described with respect to FIG. 7A. In one embodiment, the mobile computing device **102a** transfers execution of the virtual machine to the client **102b** and/or the server **106**. In another embodiment, the mobile computing device **102a** transfers execution of a resource **204** in a virtual machine to the client **102b** and/or the server **106**. In one embodiment, when the mobile computing device **102a** attaches to the client **102b**, the mobile computing device **102a** may transmit to the server **106** an identification of the attached client **102b**. The server **106** may identify a virtual machine on the client **102b**. In some embodiments, the server **106** may disconnect a resource **204** executing in a virtual machine on the mobile computing device **102a** and connect the resource **204** to the virtual machine on the client **102b**. In these embodiments, the server **106** may transmit information regarding the state of execution of the resource to the virtual machine on the client **102b**. In other embodiments, the server **106** may transfer execution of a resource executing in a virtual machine by disconnecting the virtual machine from the mobile computing device **102a** and connecting the virtual machine to the client **102b**.

In one embodiment, the server **106** provides access to a computing environment to the client **102b**. An example of such a computing environment is the XenDesktop distributed by Citrix Inc. of Ft. Lauderdale, Fla. In another embodiment, the output of the resource **204** that is executed on the server **106** for the mobile computing device **102a** is displayed as a part of the computing environment on the client **102b** through the connection **104''**. In still another embodiment, the output of the resource **204** executing on the server **106** for the mobile

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computing device **102a** is displayed on the client **102b** through the connection **104''** but not as a part of the computing environment.

Referring now to FIG. 8B, a flow diagram depicts one embodiment of the steps taken in a method for executing resources for a mobile computing device remotely on a server and displaying output from the resources on a client device. The method includes the step of connecting, by an agent on a mobile computing device **102a**, to a server **106** via a first session to execute and display output data of a resource **204** executed on the server **106** (step **810**). The method also includes the step of connecting by the agent on the mobile computing device **102a** with a client **102b** via a second session (step **812**). The method further includes the step of establishing, by an agent executing on the client **102b** a third session with the server **106** (step **814**). In one embodiment, the server **106** displays a computing environment on the client **102b**. In another embodiment, the computing environment includes a display of output generated by an execution, on a remote server **106**, of the resource **204**.

In one embodiment, an agent or application program on the mobile computing device **102a** connects to a server **106** to establish the connection **104'** (step **810**). In another embodiment, a first session is established between the mobile computing device **102a** and the server **106** for the mobile computing device **102a** to access resources **204** on the server **106**. In still another embodiment, the mobile computing device **102a** executes a resource **204** on the server **106** via the first session. In yet another embodiment, the output of the execution is displayed on the mobile computing device **102a**. In a further embodiment, the output of the execution is transmitted to a client **102b**.

The agent on the mobile computing device **102a** connects with a client **102b** via a second session over connection **104** (step **812**). In one embodiment, the second session is set up by the agent that sets up the first session. In another embodiment, the second session is set up by an agent separate from the agent that sets up the first session. In one embodiment, the first session and the second session function according to a substantially same protocol. In another embodiment, the first session and the second session function according to separate protocols. In still another embodiment, the connection between the mobile computing device **102a** and the client **102b** may be chosen from a plurality of possible connections as described with reference to FIG. 5A.

In one embodiment, an agent on the client **102b** establishes a third session between the client **102b** and the server **106** over the connection **104''** (step **814**). In another embodiment, the server **106** transmits to the client **102b** a computing environment over the connection **104''**. In an example embodiment, the computing environment is a XenDesktop distributed by Citrix Systems Inc. of Ft. Lauderdale, Fla. In one embodiment, the output data generated by the execution of the resource **204** is incorporated into a display of the computing environment as described in greater detail in connection with FIGS. 10-11. In another embodiment, the output data generated by the execution of the resource **204** is transmitted from the server **106** to the client computing device **102b** over the connection **104''**. In still another embodiment, the output data generated by the execution of the resource **204** is displayed on the client **102b** separately from the computing environment.

In one embodiment, the resource **204** is executed on the mobile computing device **102a** and output data generated by the execution of the resource **204** is transmitted to the server **106** over connection **104'** to be forwarded to the client **102b** over the connection **104''** for display. In another embodiment, execution of the resource is transferred or relocated to the

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client 102b. In still another embodiment, output data generated by the resource 204 is displayed inside the computing environment. In yet another embodiment, the execution of the resource 204 is transferred to the server 106. In one embodiment the output data from the execution on the server 106 is transmitted to the mobile computing device 102a and/or the client 102b.

FIG. 9A depicts an embodiment of a system for displaying and activating disconnected sessions between a mobile computing device and a server. In FIG. 9A, a block diagram depicts a system 900 including the mobile computing device 102 and the server 106, although any type of client may be used in place of the mobile computing device 102. In one embodiment, the mobile computing device 102 includes an input module 908, a client process 910, a network module 912, and a display module 924. The input module 908 provides an interface for a user of the mobile computing device 102 to interact with the mobile computing device 102, for example, to request the remote execution of an application 916 in a session 918 from the server 106.

Referring now to FIG. 9A, now in greater detail, a server 106 for displaying and activating disconnected sessions includes a network module 920, a data store 926, and a server process 922. The network module 920 receives authentication information associated with a user of a mobile computing device 102. The data store 926 enumerates at least one disconnected session associated with the user. The server process 922 transmits, to the mobile computing device 102, a graphical representation of the at least one disconnected session associated with the user. The server process 922 receives a request to connect to the at least one disconnected session. The server process 922 connects the mobile computing device 102 to the requested at least one disconnected session enumerated in the data store 926.

In one embodiment, a session 918 is a process, operating on the server 106, that supports the execution of one or more applications 916. In some embodiments, execution of a session 918 includes execution of a desktop application 916 from which the execution of other applications 916 can be initiated. In other embodiments, a session 918 is a session between a mobile computing device 102 and a hosted desktop provided by a virtual machine executing on a server 106. In one of these embodiments, a desktop session 918' executes within the session 918. In another of these embodiments, one or more applications 916 execute within a desktop session 918' executing within the session 918. In still other embodiments, a session 918' may execute within a second session 918. In one of these embodiments, for example, a virtual machine on a server 106 executes a session 918 and a second session 918'—such as a desktop session within which a plurality of applications 916 executes—executes within the session 918. In yet another embodiment, the session 918 includes an instance of the execution of a single application 916.

In one embodiment, the input module 908 is, for example, a graphical user interface that provides one or more icons or menu selections for a user to select. In another embodiment, at least one icon or menu selection represents a specific application 916 available for remote execution. In still another embodiment, selecting an icon or menu selection initiates the transmittal of a log-on request to the server 106 for access to that application 916. In still even another embodiment, an icon or menu selection does not represent any specific application 916, but instead represents a general server 106 log-on procedure. In yet another embodiment, the input module 108 is non-graphical user interface. In this embodiment, the user can enter a command to send a log-on request to server 106. Entering a command can include typing a predefined set of

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characters or depressing a specified key sequence on an input device (e.g., a keyboard or keypad). In one embodiment, the log-on request includes user-provided authentication information. In another embodiment, the input module 908 accepts the input of the user-provided authentication information, which can include any type of authentication information, including, without limitation, any of user name-password/PIN combinations, voice samples, one-time passcodes, biometric data, digital certificates, or smart card data. In some embodiments, the input module 908 is in communication with additional hardware peripherals to facilitate acceptance of user authentication information.

Information associated with a user may be transmitted from the mobile computing device and received by the server. In one embodiment, the input module 908 accepts authentication information and provides it to the client process 910. In another embodiment, the client process 910 manages the mobile computing device-side functionality of the remotely-executing session. In still another embodiment, the client process 910 forwards user input including the authentication information and requests for termination or disconnection of sessions 918 to the server 106. In still even another embodiment, the server 106 receives the information associated with a user of a mobile computing device 102 and authenticates the user responsive to the information. In yet another embodiment, the client process 910 processes data received from the server 106, for example, by forwarding graphical output data generated in a session 918, or a graphical representation of output data from a session 918, to the display module 924.

The network module 912 provides for communication between a mobile computing device 102 and the server 106. The network module 920 provides communication functionality for the server 106. In one embodiment, the network module 912 sends user input, such as authentication information and requests for access to, disconnection from, or termination of sessions 918 executing on the server 106. In another embodiment, the network module 912 also receives output data from the sessions 918 and forwards the output data to the client process 910. In still another embodiment, the network module 912 encapsulates user input into, and reconstitutes session output data from, a predetermined protocol for transmission to the server 106. In yet another embodiment, the network module 912 encrypts outgoing transmissions and decrypts incoming transmissions.

In some embodiments, the network module 920 receives authentication information associated with a user of a mobile computing device 102. In another embodiment, the network module 920 receives communications from the mobile computing device 102 over one or more data networks or links 921. In still another embodiment, the network module 920 transmits output data to the mobile computing device 102. In still even another embodiment, the network module 920 encrypts outgoing communications and decrypts incoming communications. In one embodiment, the network module 920 of the server 106 communicates with the network module 912 of a mobile computing device 102 over a network 104. In another embodiment, incoming communications, once decrypted or retrieved from a protocol (if necessary), are forwarded to a session 918 or to the server process 922, as appropriate.

In some embodiments, the network module 920 encapsulates outgoing communications in a protocol for transmission and retrieves incoming data from transmissions received according to a communications protocol. In one of these embodiments, network module 920 uses at least one communication protocol to encapsulate data. In another of these embodiments, a first communication protocol, capable of

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encapsulating secondary protocols used in communications between the mobile computing device and the host service, ensures that data is maintained during a disrupted network connection. In still another of these embodiments, data communicated between the mobile computing device and the host service is buffered. When, for example, a mobile computing device roams between different access points in the same network, the buffered data is maintained during the temporarily disrupted network connection. Similarly, in another example, when a mobile computing device switches between networks (e.g., from a wired network to a wireless network) the buffered data is maintained during the temporarily disrupted connection to the host service. In still even another of these embodiments, buffered data can also be maintained, for example, when the network connection is disrupted due to a failure of a server side component (e.g., a failure of a server side proxy), due to a time-out in the system, or due to other reasons. In yet another of these embodiments, the network module 920 provides session persistence and reliability by encapsulating secondary protocols within the first communication protocol.

In one embodiment, at least one previously disconnected application session already associated with the user is identified responsive to the authentication information. In another embodiment, at least one previously disconnected desktop session already associated with the user is identified responsive to the authentication information. In some embodiments, the mobile computing device 102 receives output data generated by the at least one previously disconnected session. In one of these embodiments, an application executing within the at least one previously disconnected session generates the output data. In another of these embodiments, the mobile computing device 102 generates a graphical representation of the at least one previously disconnected session using the received output data. In still another of these embodiments, the mobile computing device 102 receives a graphical representation of the output data.

The mobile computing device 102 may receive and display a graphical representation representing at least one previously disconnected session associated with the user. In one embodiment, the display module 924 displays the graphical representation of the at least one previously disconnected session to a user of the mobile computing device 102. In some embodiments, output data is displayed to the user. In other embodiments, a graphical user interface is displayed to the user with the received graphical representation. In still other embodiments, the received graphical representation incorporates a graphical user interface element. In yet other embodiments, a text-based representation of output data generated by a disconnected session is displayed to the user.

In one embodiment, the display module 924 displays the output data generated by an application 916 or a session 918 from a remotely-executing session 918. In another embodiment, the display module 924 forwards output data received from the client process 910 directly to a display device, such as the display device 124 described above in connection with FIGS. 1B and 1C, or other suitable form of display device. In some embodiments, the received output data is encrypted, encapsulated in a protocol, or both. In one of these embodiments, the display module 924 first manipulates the output data so that the output data can be interpreted by a standard display adapter such as a computer video card.

A user may request to connect to at least one previously disconnected session, and the request may be transmitted to the server. In one embodiment, a user of the mobile computing device 102 selects a graphical representation to which to connect. In another embodiment, the mobile computing

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device 102 transmits the request to connect responsive to selection of a corresponding graphical representation selected by a user. Output data generated by the at least one previously disconnected session associated with the user is received in response to the transmitted request. The output data generated by the session, and by applications executing within the session, are received and displayed as described below.

The server process 922 manages the execution and termination of sessions 918 and the connections and disconnections of those sessions 918 to the mobile computing device 102. In one embodiment, the server process 922 can initiate new sessions 918, disconnect a mobile computing device 102 from a session 918, detect a mobile computing device 102 disconnection from a session 918, locate a session 918 from which a user has disconnected, locate a session 918 to which a user of a mobile computing device 102 is connected to a client computing device 102b, receive a request to connect to a disconnected session, and connect a user to a disconnected session 918. In another embodiment, the sessions 918 are configured with a user's personal preferences and authorization privileges.

The output transmitter 924 transmits output data from a session 918 to a mobile computing device 102 through the network module 920. In one embodiment, the output transmitter 924 intercepts the output data generated in a session 918 and determines which mobile computing device 102 is connected to the session 918. If the session 918 is connected to a mobile computing device 102, the output transmitter 924 transmits the output data to the connected device via the network module 920. In one embodiment, if the session 918 is not connected to a mobile computing device 102, the output transmitter 924 discards the output data and waits to receive future output data. In another embodiment, if the session 918 is not connected to a mobile computing device 102, the output transmitter 924 disregards all further output data until the output transmitter 924 receives notification that a session 918 has connected to a mobile computing device 102. In some embodiments, as described in further detail below, if the sessions 918 are not connected to a mobile computing device 102, the output transmitter 924 transmits, to a mobile computing device 102, a graphical representation of at least one disconnected session associated with the user.

In one embodiment, the output transmitter 924 stores the data until the output transmitter 924 receives notification that the session 918 has connected to a mobile computing device 102. In another embodiment, the output transmitter 924 attempts to send output data to a mobile computing device 102 until the server process 922 notifies the output transmitter 924 that the mobile computing device 102 is disconnected from the server 106. In still another embodiment, the output transmitter 924 determines which of the mobile computing device 102 or other client, if any, the session 918 is connected to by consulting the data store 926. In yet another embodiment, the server process 922 determines to which of the mobile computing device 102 or other client, if any, the session 918 is connected by consulting the data store 926 and transmits the determination to the output transmitter 924.

At least one disconnected session already associated with the user is identified in response to the information. In one embodiment, the at least one disconnected session already associated with the user continues to execute at least one application. In another embodiment, the at least one disconnected session already associated with the user continues to execute a desktop session. In still another embodiment, a server 106 identifies the at least one disconnected session.

In one embodiment, a first session executing on a first server is identified. In some embodiments, a second session executing on a second server is identified. In one of these embodiments, one of the first session and the second session is identified as a disconnected session. In other embodiments, a second session executing on the first server is identified. In one of these embodiments, one of the first session and the second session is identified as a disconnected session.

The data store 926 includes information related to sessions 918 initiated by users. In one embodiment, the data store 926 is stored in volatile or non-volatile memory. In another embodiment, the data store 926 is distributed through multiple servers. Table 1 shows the data included in a portion of an illustrative data store 926.

TABLE 1

| | Session | | |
|----------------|----------------|--------------|--------------|
| | Session 1 | Session 2 | Session 3 |
| User ID | User 1 | User 2 | User 1 |
| Client ID | First Client | | First Client |
| Client Address | 172.16.0.50 | | 172.16.0.50 |
| Status | Active | Disconnected | Active |
| Applications | Word Processor | Data Base | Spreadsheet |
| Process Number | 1 | 3 | 2 |
| Server | Server A | Server A | Server B |
| Server Address | 172.16.2.55 | 172.16.2.55 | 172.16.2.56 |

The illustrative data store 926 in Table 1 includes data associating each session 918 with the user that initiated the session 918, an identification of the mobile computing device 102 or the client computing device 102b, if any, from which the user is currently connected to the server 106, and the internet protocol (IP) address of the mobile computing device 102 or the client computing device 102b. The illustrative data store 926 also includes the status of each session. A session 918 status can be, for example, "active" (meaning a user is connected to the session 918), or "disconnected" (meaning a user is not connected to the session 918). In another embodiment, a session status can also be set to "executing-disconnected" (meaning the user has disconnected from the session 918, but applications in the session 918 are still executing), or "stalled-disconnected" (meaning the user is disconnected and applications 916 in the session 918 are not executing, but their operational state immediately prior to the disconnection has been stored). The data store 926 further stores information indicating the applications 916 that are executing within each session 918 and data indicating a process associated with each application 916. In one embodiment, where the server 106 resides in a server farm, the data store 926 also includes the data in the last two rows of Table 1 that indicate on which server in the server farm each application 916 is or was executing, and the IP address of that server. In other embodiments, the data store 926 includes a status indicator for each application 916 in each session 918.

For example, and referring to Table 1, three sessions 918 exist, Session 1, Session 9, and Session 3. Session 1 is associated with User 1, who is currently using terminal 1. Terminal one's IP address is 172.16.2.50. The status of Session 1 is active, and in Session 1, a word processing program is being executed on Server A as process number 1. Server A's IP address is 172.16.2.55. Session 2 in Table 1 is an example of a disconnected session 918. Session 2 is associated with User 2, but Session 2 is not connected to a mobile computing device 102. Session 9 includes a database program that is executing on Server A, at IP address 172.16.2.55 as process number 3. Session 3 is an example of how a user can interact

with sessions 918 operating on different servers 106. Session 3 is associated with User 1, as is Session 1. Session 3 includes a spreadsheet program that is executing on Server B at IP address 172.16.2.56 as process number 2, whereas the session 918 included in App Session 1 is executing on Server A.

In one embodiment, the server 106 also includes a rules source 928. In another embodiment, the rules source 928 stores rules specifying a policy applicable to a user requesting access to a session 918, or to an application 916 in a session 918. In still another embodiment, the rules stored in the rules source 928 are specified at least in part by the system administrator. In still even another embodiment, a user specifies at least some of the rules stored in the rules source 928. In this embodiment, the user-specified rule(s) may be referred to as preferences. In yet another embodiment, the rules source 928 can be stored in volatile or non-volatile memory or distributed through multiple servers.

In one embodiment, a rule stored in the rule source 928, for example, might require or forbid automatic connection to disconnected sessions 918. In another embodiment, a rule might require or forbid automatic connection to active sessions 918 currently connected to a different mobile computing device 102. In still another embodiment, a rule might make a connection contingent on the mobile computing device 102 residing within a secure network. In still even another embodiment, a rule might only allow connection to sessions 918 after receiving user approval. In still another embodiment, a rule might only allow connection for a predetermined time after disconnection. In yet another embodiment, a rule may only allow connection to sessions 918 that provide access to specific applications 916.

In some embodiments, the authentication module 930 authenticates a user that attempts to log on to the server 106. In one embodiment, the authentication module 930 receives user-provided authentication information transmitted from the mobile computing device 102. In another embodiment, the authentication module 930 authenticates the user based on user-provided authentication information. In yet another embodiment, the authentication module 930 transmits, responsive to a successful authentication, the results of the authentication process (e.g., allow or deny access, the user's system ID, mobile computing device ID, user access permissions, etc.) to the server process 922.

Unintentional termination of sessions 918 resulting from imperfect network connections or users' failure to terminate their sessions 918 themselves can lead to user difficulties. In one embodiment, these difficulties are addressed by differentiating disconnection (which is treated as if the user is not done working with a session 918) from termination (which is assumed to be an intentional completion of the session) and by correlating sessions 918 with users as opposed to correlating sessions with client computers. In some embodiments, when a user is finished executing an application 916 operating in a session 918, the user can terminate a session 918. In one of these embodiments, termination generally involves the affirmative input of the user indicating that the server should no longer maintain the session 918. In another of these embodiments, affirmative user input can include selecting an "Exit" option from a menu, clicking on an icon, or entering a termination command into a command-line interface. In still another of these embodiments, in response to receiving a termination request, the server process 922 terminates the execution of the session 918 and of any application 916 within that session 918 is halted. In another of these embodiments, data related to the session 918 is also removed from the data store 926.

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In other embodiments, disconnection, either intentional or unintentional does not result in termination of sessions 918. In one of these embodiments, the application or applications operating in a session 918 are executing on the server 106 and a connection to the mobile computing device 102 is not usually necessary to continue execution of the applications 916. In another of these embodiments, the applications 916 continue to execute while waiting for a user to connect to the session 918. In still another of these embodiments, upon disconnection of a user, the server process 922 stalls the execution of the applications 916 operating in the session 918. In this embodiment, the server process 922 halts further execution of the applications 916, and the server process 922 stores the operational state of the application 916 and any data the application 916 is processing. In still even another of these embodiments, the server process 922 can selectively stall execution of specific applications 916 after a user disconnects. For example, and in one embodiment, the server continues execution of an application 916 for a fixed time period, and if a user fails to connect within that time period, the server process 922 stalls the application 916. In yet another of these embodiments, the server process 922 stalls specified sessions 918 that cannot continue executing without user input. In other embodiments, the server process 922 updates a data record associated with the application 916 or with the session 918 to include an identification of the status of the application or session.

In some embodiments, the server process 922 continues execution of the application 916 while the session 918 remains disconnected from the mobile computing device 102. In other embodiments, if the user of a mobile computing device 102 disconnects from the server 106 and then connects to the server 106 while operating the mobile computing device 102, the client computing device 102b, or a second client computing device 102n (not shown), the server process 922 can connect the user to one or more previously initiated, non-terminated session(s) 918 associated with the user, and reinitiate execution of any stalled applications 916.

In one embodiment, the server process 922 detects a disconnection. A user can intentionally and manually instruct the server to disconnect a session 918 from the mobile computing device 102. For example, in one embodiment, sessions 918 provide a menu option for disconnection (as distinguished from termination above) that a user can select. The server process 922 can also detect an unintentional disconnection. For example, in one embodiment, the network module 920 of the server 106 informs the server process 922 when a predetermined number of data packets transmitted by the network module 920 to a mobile computing device 102 have not been acknowledged by the mobile computing device 102. In another embodiment, the mobile computing device 102 periodically transmits a signal to the server 106 to confirm that a connection is still intact. If the server process 922 detects that a predetermined number of expected confirmation signals from a mobile computing device 102 have not arrived, the server process 922 determines that the mobile computing device 102 has disconnected. If the server process 922 detects that a user has disconnected from a session 918, either intentionally, or unintentionally, the entry in the data store 926 related to the disconnected session 918 is modified to reflect the disconnection.

A graphical representation of the at least one disconnected session associated with the user may be displayed to the user. The server process 922 transmits, to the client 102, a graphical representation of the at least one disconnected session associated with the user. In one embodiment, the graphical representation displays a representation of output data gen-

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erated by an executing, disconnected session. In another embodiment, the graphical representation displays a representation of output data generated by an application executing in a disconnected session. In still another embodiment, the server process 922 transmits, to a mobile computing device 102, output data generated by an executing, disconnected session. In still even another embodiment, the mobile computing device 102 displays, to the user, a graphical representation of the output data. In yet another embodiment, the server process 922 transmits, to the mobile computing device 102, a graphical representation comprising a user interface element. In some embodiments, an output transmitter 924 transmits, to the mobile computing device 102, the output data generated by an executing, disconnected session.

In one embodiment, the server process 922 transmits, to the mobile computing device 102, a representation of a state of the at least one disconnected session associated with the user. In another embodiment, the server process 922 transmits, to the mobile computing device 102, a description of a state of the at least one disconnected session associated with the user. In still another embodiment, the server process 922 transmits, to the mobile computing device 102, a text-based description of a state of the at least one disconnected session associated with the user.

In some embodiments, the server process 922 transmits, to the mobile computing device 102 output data generated in the at least one disconnected session. In one of these embodiments, the mobile computing device 102 generates the representation, graphical or text-based, of the output data received from the at least one disconnected session. In another of these embodiments, the mobile computing device 102 displays the output data as described above. In still another of these embodiments, the mobile computing device 102 displays the representation of the output data in a window generated by an internet browser application. In yet another of these embodiments, the mobile computing device 102 replaces an existing representation of output data with an updated version of the representation. In some embodiments, the representation 950 (not shown) of the output data is graphical. In other embodiments, the representation of the output data is text-based.

In some embodiments, a graphical representation 950 may depict the output of multiple applications executing within a disconnected session 918. In one of these embodiments, the graphical representation 950 depicts the output of multiple applications executing from a desktop application, which is provided by a session 918. In other embodiments, a plurality of graphical representations 950 is displayed to the user of the mobile computing device 102. In one of these embodiments, a first graphical representation 950 in the plurality of graphical representations depicts a first type of session 918 and a second graphical representation 950' (not shown) in the plurality of graphical representations depicts a second type of session 918. For example, the first graphical representation 950 may depict the application-output data generated by a single application executing in a session 918, while the second graphical representation 950' may depict the output data generated by a plurality of applications executing within a hosted desktop session 918'. In still other embodiments, a single graphical representation 950 is depicted.

In some embodiments, the server process 922 identifies a change in the at least one disconnected session associated with the user and transmits a modified version of the at least one disconnected graphical representation of the at least one session displayed to the user, responsive to the identified change. In one of these embodiments, the server process 922 requests an identification of a change in the at least one

disconnected session. In another of these embodiments, the server process 922 requests the identification of the change from a server executing the session 918. In still another of these embodiments, the server process 922 requests, after a time interval, an identification of a second change in the at least one session associated with the user. In still even another of these embodiments, the server process 922 polls a server executing the session 918 for changes in the at least one application session. In yet another of these embodiments, the server process 922 updates, after a time interval, the graphical representation of the at least one application session displayed to the user, responsive to an identification of a second change in the at least one application session associated with the user.

In other embodiments, the server process 922 queries the data store 926 to determine that a previously connected session has become disconnected from a mobile computing device 102. In one of these embodiments, the server process 922 instructs the output transmitter 924 to transmit, to the mobile computing device 102, the output data generated by the session 918 prior to the disconnection.

In some embodiments, the server process 922 receives a request for the identification of the change. In one of these embodiments, the server process 922 receives the request from the mobile computing device 102. In another of these embodiments, the server process 922 transmits the identification of the change to the mobile computing device 102. In other embodiments, the server process 922 transmits, to the mobile computing device 102, an updated graphical representation of the at least one session, responsive to an identification of a change in the at least one session associated. In still other embodiments, the server process 922 transmits, to the mobile computing device 102, output data generated in the session 918. In one of these embodiments, the mobile computing device 102 generates the graphical representation of the output data and displays the graphical representation to the user.

In some embodiments, the mobile computing device 102 requests, from the server 106, the identification of a change in the at least one previously disconnected session associated with the user. In other embodiments, the mobile computing device 102 requests, from a server 106, which executes the at least one previously disconnected session, the identification of a change in the at least one previously disconnected session associated with the user. In still other embodiments, the mobile computing device 102 requests, after a time interval, an identification of a change in the at least one previously disconnected session associated with the user. In still even other embodiments, the mobile computing device 102 polls a server for an identification of a change in the at least one previously disconnected session associated with the user.

In some embodiments, the mobile computing device 102 receives an identification of a change in the at least one previously disconnected session. In other embodiments, the mobile computing device 102 receives output data generated by a session during a time interval. In still other embodiments, the mobile computing device 102 receives a modified version of the graphical representation. In yet other embodiments, the mobile computing device 102 displays a modified version of the graphical representation.

Referring now to FIGS. 9B and 9C, a flow diagram depicts one embodiment of the steps taken in a method for displaying, activating, and providing remote access to disconnected sessions. The steps in the lefthand column may be taken, for example, by a client, such as a mobile computing device. The steps in the righthand column may be taken, for example, by a server. The method includes the step of transmitting infor-

mation associated with a user. (step 940) The method includes the step of receiving information associated with a user. (step 942) At least one disconnected session already associated with the user is identified in response to the information. (step 944) A graphical representation of at least one disconnected session associated with the user is transmitted to the user. (step 946) A graphical representation representing at least one disconnected session associated with the user is received. (step 948) The graphical representation is displayed to the user. (step 950). A request to connect to the at least one previously disconnected session is transmitted. (step 952) A request from a user to connect to the at least one disconnected session is received. (step 954) A connection is established between a client computer operated by the user and the at least one disconnected session in the request. (step 956) Output data generated by the at least one disconnected session associated with the user is received in response to the transmitted request. (step 958)

Referring to FIG. 9B, and in greater detail, information associated with a user is transmitted. (step 940) In some embodiments, the information is a log-on request. In some embodiments, the information is a log-on request for access to a resource. In other embodiments, the information is a general log-on request for a server. In various embodiments, information may include authentication information. The authentication information may be any type of authentication information, include, for example, any username-password/PIN combinations, voice samples, one-time passcodes, biometric data, digital certificates, or smart card data.

In some embodiments, the information is accepted from a user by an input module, such as input module 208, and provided to a client process, such as client process 910. In some embodiments, the information is forwarded to server by a client process, a network module, or a client process and network module in communication with one another. In any embodiments described herein where information is transmitted, the information may be encapsulated in a predetermined protocol prior to transmission. In any embodiments described herein where information is transmitted, the information may be encrypted prior to transmission. In various embodiments, the information is transmitted over a data network or link.

Referring to FIG. 9B, and in greater detail, information associated with a user is received. (step 942) In various embodiments, the information is received by a server. In any embodiments described herein where information is received, the information may be decrypted. In some embodiments, the user is authenticated according to the received information. The information may be analyzed to authenticate the user according to any known method. For example, a hash function may be performed upon the information and the results compared with entries stored in a look-up table to determine if the user should be authenticated.

Referring to FIG. 9B, and in greater detail, at least one disconnected session already associated with the user is identified in response to the information. (step 944) In various embodiments, the information associated with a user includes information that identifies the user. In many embodiments, sessions may be stored in a database, such as a data store. Each session may include information about the session's status, e.g. active, disconnected, terminated, or any other known status. Each session may include information about a user corresponding to the session. The database may be searched for sessions that have a disconnected status and that correspond to the user. Information about the sessions, such as the sessions' server addresses and process numbers, may be stored in a memory or other buffer.

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Referring to FIG. 9B, and in greater detail, a graphical representation of at least one disconnected session associated with the user is transmitted to the user. (step 946) In various embodiments, the graphical representation is generated by at least one disconnected session. In some embodiments, the graphical representation is generated by at least one application executing within the at least one disconnected session. The graphical representation may be a graphical-based or text-based representation of the at least one disconnected session. In some embodiments, the graphical representation includes a description of each of the disconnected sessions. In one embodiment, the graphical representation displays output data or a representation of output data generated by at least one disconnected session. In another embodiment, the graphical representation displays output data or a representation of output data generated by an application executing in at least one disconnected session. In various embodiments, the graphical representation includes a user interface element. In many embodiments, the graphical representation of at least one disconnected session associated with the user is transmitted using an output transmitter. In some embodiments, the output transmitter intercepts output data generated by at least one executing, disconnected session and transmits the output data.

Referring to FIG. 9B, and in greater detail, a graphical representation representing at least one disconnected session associated with the user is received. (step 948) In various embodiments, the graphical representation is received by a client process, a network module, or a client process and network module in communication with one another. In some embodiments, the graphical representation is manipulated into a format suitable for interpretation by a standard display adapter. In many embodiments, the graphical representation is stored in a frame buffer. Further, the graphical representation is displayed to the user. (step 950). In many embodiments, the graphical representation is displayed on a display module 924. In some embodiments, the graphical representation is displayed on a native display 201 of a mobile computing device 102. In other embodiments, the graphical representation is displayed on an external display device 202. In some embodiments, a client process transmits the graphical representation to a display module 924 for display on the device.

Referring to FIG. 9C, and in greater detail, a request to connect to the at least one previously disconnected session is transmitted. (step 952) In various embodiments, the request may include the server address, process number, or any other information about the disconnected sessions the user wishes to connect to. The user may make a request by selecting the graphical representation, in part or in whole, of a disconnected session. For example, the user may select an icon corresponding to the disconnected session to request connection. In another example, the user may select a disconnected session from a list of enumerated disconnected sessions. In yet another example, the user may select a disconnected session from a menu of disconnected sessions.

Referring to FIG. 9C, and in greater detail, a request from a user to connect to at least one disconnected session is received (step 954) and a connection is established between a client computer operated by the user and at least one disconnected session in the request. (step 956) In many embodiments, a server process may establish the connection. The connection may be established by forming a connection using the server address, the process number, and the client address. The connection may be established if the requested connection is consistent with a policy. For example, the connection may be established if the policy permits automatic re-connec-

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tion of disconnected sessions. In another example, the connection may be established if the policy requires a client to reside on a secure network before a connection may be made, and the client does reside on a secure network. In some embodiments, when the connection is established, applications that may have stalled on the previously disconnected session may be re-executed.

Referring to FIG. 9C, and in greater detail, output data generated by the at least one disconnected session associated with the user is received in response to the transmitted request. (step 958) In various embodiments, the output data may be received from storage, such as a buffer, in an output transmitter. In other embodiments, the output data may be received from an output transmitter that intercepts output data generated by applications executing in the sessions and transmits the output data to a client.

Referring now to FIG. 10A, a block diagram depicts one embodiment of a system for generating a computing environment on a remote machine for display on a local machine. In brief overview, the system includes a first client 102a, a first agent 1002, a second client 102b, and a second agent 1010. The first agent 1002, executing on the first client 102a, generates a computing environment 1004, which includes a plurality of windows 1006a-1006n and provides access to i) a resource 1015 available to a user of the second client 102b and provided by the first client 102a, and ii) a resource 1020 provided by the second client 102b that is available to the user of the second client 102b. The first agent 1002 generates a proxy window 1008 for display in the computing environment 1004. The proxy window 1008 represents a local window 1014 on the second client 102b that displays output data generated by the resource 1020 provided by the second client 102b. The proxy window 1008 has a z-order entry in a z-order list associated with the plurality of windows 1006a-n in the computing environment 1004. The second agent 1010 on the second client 102b receives, from the first agent 1002, at least one entry in the z-order list associated with the computing environment 1004 and transmits, to the first agent 1002, an identification of a change to window attribute data associated with the window 1014 on the second client 102b for modification, by the first agent 1002, of the computing environment 1004.

In one embodiment, the first client 102a is a mobile computing device. In another embodiment, the second client 102b is a client computing device. In still another embodiment, one of the first client 102a and the second client 102b may be a server 106. In still even another embodiment a resource executes on an mobile computing device 102a. In yet another embodiment, the output data generated by an execution of a resource on the mobile computing device 102a is displayed on the second client which may be a client computing device. In some embodiments, the output data generated by an execution on a client 102b of a resource 204 is integrated into a display on the mobile computing device.

Referring now to FIG. 10A, and in greater detail, the first agent 1002, executing on the first client 102a, generates a computing environment 1004, which includes a plurality of windows 1006a-1006n and provides access to i) a resource 1015 available to a user of the second client 102b and provided by the first client 102a, and ii) a resource 1020 provided by the second client 102b that is available to the user of the second client 102b. In one embodiment, the first client 102a is a server 106. In another embodiment, the second client 102b is a client device 102, connecting to the server 106 to access one or more resource available to a user of the second client 102b.

In one embodiment, a resource **1015**, **1020** comprises a program, an application, a document, a file, a plurality of applications, a plurality of files, an executable program file, a desktop environment, a computing environment, or other resource made available to a user of the second client **102b**. The resource **1020** may be delivered to the second client **102b** via a plurality of access methods including, but not limited to, conventional installation directly on the second client **102b**, delivery to the second client **102b** via a method for application streaming, delivery to the second client **102b** of output data generated by an execution of the resource **1020** on a third machine **106'** and communicated to the second client **102b** via a presentation layer protocol, delivery to the second client **102b** of output data generated by an execution of the resource **1020** via a virtual machine executing on a first client **102a**, or execution from a removable storage device connected to the second client **102b**, such as a USB device. In some embodiments, the second client **102b** transmits output data generated by the execution of the resource **1020** to another client machine **102'**.

In some embodiments, a user of a second client **102b** connects to a first client **102a** and views a display on the second client **102b** of a local version **1012** of a computing environment **1004**, comprising a plurality of windows **1006a-n**, generated on the first client **102a**. In one of these embodiments, at least one resource is provided to the user by the first client **102a** and displayed in the computing environment **1004**. However, there may be resources that the user executes on the second client **102b**, either by choice, or due to a policy or technological requirement. In another of these embodiments, a user may invoke a local application from the remote desktop interface generated by the first client **102a** and have the local application appear in the same desktop environment as the remote applications provided by the first client **102a**. In still another of these embodiments, the user of the second client **102b** would prefer an integrated desktop environment providing access to all of the resources available to the user, instead of separate desktop environments for resources provided by separate machines. For example, a user may find navigating between multiple graphical displays confusing and difficult to use productively. Or, a user may wish to use the data generated by one application provided by one machine in conjunction with another resource provided by a different machine. In another of these embodiments, requests for execution of a resource, windowing moves, application minimize/maximize, and termination of executing resources may be controlled by interacting with a computing environment that integrates the display of the remote resources and of the local resources. In yet another of these embodiments, an application or other resource accessible via an integrated desktop environment **1004**—both those generated on the second client **102b** and those generated on the first client **102a**—is shown on the computing environment **1004** as if it were executing on, or executable from, the computing environment. For example, a resource may also appear in a listing of available resources provided in a Start Menu, a shortcut may be provided on the desktop or the Quick Launch menu, and the resources can be launched, selected and interacted with in the same way as an application provided by the first client **102a**.

In some embodiments, a single computing environment **1004** is displayed. In one of these embodiments, the computing environment **1004** is displayed as a full-screen desktop. In other embodiments, a plurality of computing environments **1004** is displayed. In one of these embodiments, one or more of the computing environments are displayed in non-full-screen mode on one or more display devices **124**. In another

of these embodiments, the computing environments are displayed in full-screen mode on individual display devices. In still another of these embodiments, one or more of the computing environments are displayed in full-screen mode on one or more display devices **124**. In yet another of the embodiments, a resource provided by the second client **102b** may be integrated with one of the plurality of computing environments **1004**.

In some embodiments, the first agent **1002** generates a computing environment **1004** including a plurality of windows **1006a-1006n**. In one of these embodiments, a window **1006a** in the plurality of windows **1006** displays the output data generated by an execution of a resource provided by the first client **102a**. In another of these embodiments, a window **1006b** in the plurality of windows **1006a-1006n** displays the output data generated by an execution of a resource provided by a third machine **106'**, as discussed in further detail below, in connection with FIGS. **12A** and **12B**. In still another of these embodiments, a window **1006c** in the plurality of windows **1006a-1006n** depicts a taskbar from a desktop environment. In still even another of these embodiments, a window **1006d** represents a menu, such as a Start menu or a context-specific menu associated with an application. In yet another of these embodiments, a window **1006e** in the plurality of windows **1006a-n** has a z-order entry such that it is displayed beneath the other windows in the plurality of windows **1006a-n** and depicts a desktop. In other embodiments, the first agent **1002** transmits, to the second agent **1010**, window attribute data associated with each of the plurality of windows **1006a-n**. In one of these embodiments, the second agent **1010** displays a local version of the plurality of windows **1006a-n** having window attribute data corresponding to the window attribute data received from the first agent **1002**.

In one of these embodiments, the graphical display and the window attribute data for the plurality of windows **1006a-n** and for the computing environment **1004** are transmitted to the second agent **1010** for generation of a local version of the computing environment **1004**. In another of these embodiments, the second agent **1010** displays, to a user of the second client **102b**, a local version **1012** of the plurality of windows **1006** and the computing environment **1004**.

Referring ahead to FIG. **10B**, a block diagram depicts one embodiment of a system in which the first agent **1002** integrates resources from various sources into a computing environment **1004**. In some embodiments, and as shown in FIG. **10B**, the first agent **1002** may receive the identification of the resources available to a user of the second client **102b** from a plurality of servers **106**. In one of these embodiments, the first agent **1002** receives an identification of the available resources from machines **106'**, **106''**, **106'''**, and **106''''**.

In one of these embodiments, the first client **102a** receives an identification of the available resources from server **106'**, receives the output data generated by an execution of the resource on server **106'** and transmits the output data so generated to second client **102b**. In another of these embodiments, the first agent **1002** receives only the identification of the available resources from the machine **106''**, and the machine **106''** transmits the output data generated by an execution of the resource to the second client **102b**.

In one of these embodiments, the first agent **1002** receives, from a machine **106'''**, an identification of resources available to the second client **102b**. In another of these embodiments, the first agent **1002** receives, from the second agent **1010**, an identification of available resources from the machines **106'''** and **106''**. In still another of these embodiments, the second client **102b** receives, via a method for resource streaming, the available resource from the server **106''''**. In this embodiment,

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the second client **102b** executes the resource locally and the graphical output data is integrated with the computing environment **1004**. In still even another of these embodiments, the first client **102a** receives an identification of the available resources from server **106'''**, and receives via a method for resource streaming, the available resource from machine **106'''** and transmits the output data generated by an execution of the resource to the second client **102b**. In other embodiments, the first agent **1002** receives, from the second agent **1010**, an identification of a resource **1020** available to the user of the second client **102b** for integration into the computing environment **1004**.

In one embodiment, executing a resource provided by the second client **102b** may allow a user to leverage a characteristic of the second client **102b** that is not provided by the first client **102a**; for example, the second client **102b** may have more appropriate processing ability, graphics functionality, bandwidth, or license rights for accessing the resource than the first client **102a**. In another embodiment, the first client **102a** may lack the ability to execute the resource; for example, because only the user of the second client **102b** owns an application or owns a resource, such as an operating system, required to execute the application. In still another embodiment, the resource **1020** is a resource such as an application or desktop environment installed on the second client **102b** via a method for streaming the application to the second client **102b** from a third machine **106'**. In still even another embodiment, the resource **1020** is a resource such as an application or desktop environment whose output data the second client **102b** receives via a presentation layer protocol communication with a third machine **106'**. In yet another embodiment, the first agent **1002** receives an identification of a conferencing or Internet-communication application; a user peripheral, such as a media player, a digital camera or a web camera; or a processor-intense, data-intense, or graphics-intense application, such as a media-editing application or a computer-aided design application.

Referring back to FIG. **10A**, the first agent **1002** incorporates the identification of the resource **1020** into the computing environment **1004**. In one of these embodiments, the first agent **1002** adds a program execution shortcut to a menu for requesting execution of resources, the program execution shortcut corresponding to the identified resource **1020**. In another of these embodiments, the first agent **1002** generates a graphical representation, such as an icon, associated with the resource **1020** for display in the computing environment **1004**. The first agent **1002** may alternatively receive the graphical representation from the second agent **1010** for display in the computing environment **1004**. In still another of these embodiments, a user requests execution of a resource **1020** by interacting with a program execution shortcut or a graphical representation displayed in the local version of the computing environment **1004**.

In one embodiment, the first agent **1002** receives the request for execution of a resource **1020**, responsive to the user interaction with a program execution shortcut or a graphical representation, and sends the request for execution to the second agent **1010**. In another embodiment, a user requests execution of a resource by interacting with the local display **1012** of the computing environment **1004**; for example, by selecting a graphical representation of a file, document, uniform resource locator, or other resource, displayed by the desktop environment.

The first agent **1002** generates a proxy window **1008** for integration into the computing environment **1004**. In one embodiment, the first agent **1002** is referred to as a proxy window management component **1002**. In another embodi-

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ment, the proxy window management component **1002** is responsible for making the proxy window **1008** conform to client-initiated changes to window attribute data. In still another embodiment, the proxy window management component **1002** is responsible for monitoring any desktop-initiated changes to window attribute data and communicating them to the second agent **1010**, which applies them to the corresponding local application window **1014**.

In yet another embodiment (not shown in FIG. **10A**), the proxy window management component **1002** provides additional functionality. In one of these embodiments, such functionality may include a MICROSOFT Active Accessibility (MSAA) hook and other monitoring mechanisms to detect new application windows and window attribute data changes initiated on the desktop. In another of these embodiments, the proxy window management component **1002** may further include support for launching published applications. In still another of these embodiments, the proxy window management component **1002** may send updates initiated from the remote machine **106** [desktop] regarding changes to window attribute data to the second agent **1010** where the updates will be applied to the local window **1014**, and to the local displays of the plurality of windows **1006a-n**. In still even another of these embodiments, the proxy management component **1002** may be enabled to apply client-initiated updates to window attribute data associated with proxy window **1008** and to the plurality of data objects **1006a-n**. In yet another of these embodiments, the proxy management component **1002** may remove proxy windows when the client connection disappears.

In some embodiments, the first agent **1002** and the second agent **1010** include a hooking component for intercepting window-related messages. For example, and in some embodiments, an agent executing on a machine **102** or **106** on which the MICROSOFT WINDOWS operating system executes may use a version of the MICROSOFT Active Accessibility hook to monitor relevant window events. For example, and in other embodiments, an agent may include a MICROSOFT Computer-based Training (CBT) window hook, or other hooking mechanisms, to intercept and monitor window events.

The proxy window **1008** represents a window **1014** on the second client **102b** that displays output data generated by the resource **1020** provided by the second machine. The proxy window **1008** has a z-order entry in a z-order list associated with the plurality of windows **1006a-n** in the computing environment **1004**. In one embodiment, the proxy window **1008** has a traditional window visual state—position, size, Z-order, focus state, minimized/normal/maximized state—and a taskbar button, and appears in the remote desktop Alt-TAB selection dialog. In another embodiment, the proxy window **1008** responds to requests, initiated by the remote desktop, to change visual state or to invoke its taskbar menu. In still another embodiment, the visual state of the local application window **1014** is synchronized with the visual state of the corresponding proxy window **1008**. In still even another embodiment, the proxy window **1008** can pass visual state change requests to the second agent **1010**, via the first agent **1002**, without needing to apply them to itself.

In one embodiment, the first agent **1002** does not transmit the proxy window **1008** to the second agent **1010**, only window attribute data associated with the proxy window **1008**. In another embodiment, the proxy window **1008** does not need to be painted on the computing environment **1004**, or can be painted very efficiently e.g. in a uniform color. In still another embodiment, the first agent **1002** is aware of the clipping

regions associated with the proxy window **1008** and does not send window attribute data for those regions.

The second agent **1010** on the second client **102b** receives, from the first agent **1002**, at least one entry in the z-order list associated with the computing environment **1004**. The second agent **1010** transmits, to the first agent **1002**, an identification of a change to window attribute data associated with the window **1014** on the second client **102b** for modification, by the first agent **1002**, of the computing environment **1004**. In one embodiment, the second agent **1010** is an integrated window management component **1010** executing on the second client **102b** that enumerates, monitors, and manages local windows **1014** that are integrated into the remote desktop **1004**. In another embodiment, the integrated window management component **1010** manages all local windows **1014** that are integrated into the remote desktop **1004**. In still another embodiment, the integrated window management component **1010** communicates window existence and client-initiated visual state changes over a virtual channel to the first agent on the first client **102a**.

In yet another embodiment, the integrated window management component **1010** provides additional functionality. In one of these embodiments, such functionality may include a MICROSOFT Active Accessibility (MSAA) hook and other monitoring mechanisms to detect new application windows and window attribute data changes initiated on the client. In still another of these embodiments, the proxy window management component **1002** may send updates initiated from the client **102a** regarding changes to window attribute data to the first agent **1002** where the updates will be applied to the proxy window **1008**, and to the local displays of the plurality of windows **1006a-n**. In still even another of these embodiments, the proxy management component **1002** may be enabled to apply desktop-initiated updates to window attribute data associated with local window **1014** and to the local displays of the plurality of windows **1006a-n**.

In some embodiments, a first client **102a** and a second client **102b** communicate using a presentation layer protocol, for example, by communicating via the ICA protocol, or the RDP protocol. In one of these embodiments, the first agent **1002** and the second agent **1010** exchange graphical data, i.e., the data actually displayed in each window on the desktop environment, via a first virtual channel. In another of these embodiments, the first virtual channel is an ICA virtual channel. In still another of these embodiments, information about window positioning, window size, z-ordering of window and other such information is communicated between the first client **102a** and the second client **102b** via a second virtual channel. In yet another of these embodiments, the second virtual channel is an ICA virtual channel. In other embodiments, the first agent **1002** and the second agent **1010** exchange window attribute data. In one of these embodiments, the first agent **1002** and the second agent **1010** also exchange graphical data. In another of these embodiments, a third agent executing on the first client **102a** and the second agent **1010** exchange graphical data. In still another of these embodiments, a third agent executing on the first client **102a** and a fourth agent executing on the second client **102b** exchange graphical data.

Referring now to FIG. 11A, a flow diagram depicts one embodiment of the steps taken in a method for generating a computing environment on a remote machine for display on a local machine. In a networked computing system including a remote machine and a local machine used by a user, a method for generating a computing environment on the remote machine for display on the local machine, the computing environment providing integrated access both to resources

provided by the local machine and to resources provided by the remote machine, includes the step of monitoring, by a first agent executing on a first machine, a computing environment for display on a second machine, the computing environment comprising a plurality of windows and providing access to i) a resource provided by the first machine that is available to a user of the second machine and ii) a resource provided by the second machine that is available to the user of the second machine (step **1102**). The first agent generates a proxy window representing a window on the second machine that displays output data generated by the resources provided by the second machine, the proxy window having a z-order entry in a z-order list associated with the plurality of windows in the computing environment (step **1104**). The first agent transmits, to a second agent on the second machine, at least one entry in the z-order list associated with a window in the plurality of windows in the computing environment (step **1106**). The first agent receives an identification of a change to window attribute data associated with the window on the second machine (step **1108**). The first agent modifies the computing environment, responsive to the identification of the change (step **1110**).

A first agent executing on a first machine monitors a computing environment for display on a second machine, the computing environment comprising a plurality of windows and providing access to i) a resource provided by the first machine that is available to a user of the second machine and ii) a resource provided by the second machine that is available to the user of the second machine (step **1102**). In one embodiment, the first agent **1002** monitors the generation and modification of the computing environment **1004** and of a plurality of windows **1006a-n** providing access to a plurality of resources **1015** executing on remote servers, such as the first client **102a**, and to at least one resource **1020** provided by the second client **102b**.

The first agent generates a proxy window representing a window on the second machine that displays output data generated by the resources provided by the second machine, the proxy window having a z-order entry in a z-order list associated with the plurality of windows in the computing environment (step **1104**). In one embodiment, the local window **1014** is reflected into the remote desktop window list using the proxy window **1008**, which has dimensions, position, Z-order value and focus state in the computing environment **1004**. These window attributes are kept in synch between the second client **102b** and the first client **102a**.

In some embodiments, the second agent **1010** receives an identification of a region in the computing environment corresponding to a region on the local display **1012** associated with a local resource **1020**. In one of these embodiments, the second agent **1010** receives the identification from the first agent **1002**. In another of these embodiments, described in additional detail below, the second agent **1010** identifies the region responsive to information received from the first agent **1002**. In still another of these embodiments, as described in additional detail below, the second agent **1010** identifies the region responsive to identifying a color key in a communication from the first agent **1002**.

In some embodiments, the local display **1012** is a single window that displays the graphical output data of the computing environment **1004**, including the window output for the plurality of windows **1006a-n**. In one of these embodiments, an individual window **1006a** does not need to have a corresponding seamless window on the client. In another of these embodiments, the local display **1012** is maintained as the topmost window, thus keeping local applications underneath the local display **1012** in the client Z-order. In still

another of these embodiments, a region of local display **1012** is shown as transparent to allow the correct parts of a local window **1014** to show through the local display **1012**, as if the local window **1014** were on the computing environment **1004**. In still even another of these embodiments, the proxy window **1008** is displayed on a region of the computing environment **1004** corresponding to the region of local display **1012** which is to be transparently displayed. In yet another of these embodiments, the transparent region is referred to as a clipping region.

In some embodiments, to identify the areas to be made transparent, the first agent **1002** uses the proxy window **1008** to identify a clipping region. In one of these embodiments, the first agent **1002** intercepts a paint request on the computing environment **1004**. In another of these embodiments, the first agent **1002** transmits, to the second agent **1010**, an identification of a clipping region.

In other embodiments, the second agent **1010** identifies the areas of local display **1012** to be displayed by the local resource **1020**. In one of these embodiments, the second agent **1010** identifies the areas responsive to information received from the first agent **1002**. In another of these embodiments, the second agent **1010** identifies a key received from the first agent **1002**, such as a color key or an identifiable pattern or tag identifying a clipping region.

In still other embodiments, the second agent **1010** ensures that the resource **1020** paints output data to the appropriate local window **1014**, which is located in a region corresponding to the clipping region on the computing environment. In one of these embodiments, the second agent **1010**, in communication with a window management component, ensures that the local display **1012** is kept topmost and displays the graphical output data associated with the computing environment **1004**, other than the output data that would be displayed in a clipping region. In another of these embodiments, the second agent **1010** instructs a window management component to regard an instruction to paint a particular color or pattern to a region (for example, to a region of the local display **1012**) as an instruction to keep the region transparent. This color key may include an alpha value (e.g., a 32-bit {R,G,B,alpha} rather than a 104-bit {R,G,B} value) which can be used to distinguish it from all non-transparent colors (for resources that don't use partial transparency).

In yet other embodiments, the agent **1002** paints a clipping region for a proxy window **1008** by responding to a paint request from a window management component to the proxy window by painting the window in a color key. In one of these embodiments, the agent **1010** associates a paint request in a color key with the appropriate local application window. In another of these embodiments, the agent **1010** also needs to use paint requests in a different color for a (part of) an existing clipping region to remove the painted region from the associated clipping region.

In some embodiments, the first agent **1002** may paint a clipping region in the color key rather than send a z-order entry to the second agent **1010**. In other embodiments, the first agent **1002** sends at least one z-order entry for a proxy window **1008** associated with a local window **1014**. In one of these embodiments, the second agent **1010** ensures that a local window **1014** has the same relative Z-order relationship on the client as the corresponding proxy window **1008** does on the first client **102a**, i.e. if proxy window **1008** is below proxy window **1008'** on the first client **102a** (regardless of how many server windows there are, and whether they are above or below either A or B), then the second agent **1010** ensures that a local window **1014** is below a local window **1014'**.

In other embodiments, the windows underneath the local display **1012** show through wherever the local display **1012** is painted in the color key. In one of these embodiments, the second agent **1010** maintains the local windows in the appropriate relative Z-order so that they will paint correctly and a window that's above another will correctly occlude the other even though both occupy the entire clipping region. In another of these embodiments, the second agent **1010** also ensures that user input will be directed to the correct window—for example a mouse click on a transparent region will be sent to the underlying window, not the local display **1012**.

In some embodiments, the first agent **1002** transmits to the second agent **1010** an identification of a clipping region for each proxy window **1008** in a computing environment **1004**. In one of these embodiments, the second agent **1010** directs the local resource **1020** to paint output data to the region of local display **1012** corresponding to the clipping region. In another of these embodiments, directing the local resource **1020** to paint output data to a region of the local display **1012** avoids the need for transparency. In still another of these embodiments, the first agent **1002** identifies a clipping region on the computing environment **1004** that corresponds to a region displaying local window **1014**. In still even another of these embodiments, the first agent **1002** uses a color key or identifiable pattern or tag as described above to tag a clipping region. In one of these embodiments, the agent **1002** or the agent **1010** associates a paint request in a color key with the appropriate local application window. In another of these embodiments, the agent **1002** or the agent **1010** responds to paint requests in a different color for a (part of) an existing clipping region for an application window by removing the newly painted region from the associated clipping region. In still another of these embodiments, the agent **1002** or agent **1010** associates a different color key for each local window. In yet another of these embodiments, the second agent **1010** identifies a clipping region responsive to information received from the first agent **1002**.

In some embodiments, the first agent **1002** may paint a clipping region in a color key rather than send a z-order entry to the second agent **1010**. In other embodiments, the first agent **1002** may send an identification of a clipping region to the second agent **1010** rather than send a z-order entry to the second agent **1010**. In still other embodiments, the first agent **1002** may send information other than a z-order entry to agent **1010** that allows agent **1010** to identify a clipping region rather than send a z-order entry to the second agent **1010**. In yet other embodiments, the first agent **1002** does not send a z-order entry to the second agent **1010** at all.

In other embodiments, the second agent **1010** ensures that the local display **1012** is maintained topmost in the local desktop environment. In one of these embodiments, the local display **1012** is used to show all of the remote desktop graphics output including areas belonging to local window **1014**. In another of these embodiments, local windows never show through. In still another of these embodiments, when the second agent **1010** receives output data not containing the color key for a portion of a clipping region associated with a local window, the second agent **1010** removes the output region from the clipping region for that window.

In still other embodiments, the second agent **1010** directs the local resource **1020** to paint the output data it generates to a region in the local display **1012** corresponding to the region identified by the first agent **1002** as a clipping region. In one of these embodiments, the second agent **1010**, in communication with a window management component, sends the local resource **1020** a WM_PAINT message for a display context that references a clipping region on the local display

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1012. In another of these embodiments, the second agent **1010** sends the messages for any updated portions of a local window's associated clipping region whenever portions of the clipping region change. In still another of these embodiments, the second agent **1010** sends the paint messages in a periodic refresh loop as local windows are always covered by the local display **1012** and can no longer asynchronously update their regions that are visible on the client display. In still even another of these embodiments, the second agent **1010** ensures that user input in clipping regions (including mouse clicks and, where appropriate, keyboard events) are redirected by the local display **1012** to the corresponding local application window. This means detecting mouse events in clipping regions, determining which local window is associated with the mouse event coordinates and sending the event to that window at those coordinates.

As described above, in some embodiments, a clipping region is identified. In one of these embodiments, an agent **1002** or **1010** calculates a clipping region responsive to information associated with the computing environment, including a list of windows, their Z-order, size & position (and, for non-rectangular windows, their shape). In another of these embodiments, the agent **1002** or **1010** acquires the information from one or more sources including, but not limited to, the seamless virtual channel, data used by the Headless Client, subclassing windows, Microsoft Active Accessibility (e.g. using WinEvents and MSAA hooking) and by hooking various Windows APIs. In still another embodiment, the agent **1002** or **1010** identifies a clipping region, or portion of a clipping region, by hooking or responding to window messages (including WM_PAINT, WM_NCPAINT, WM_ERASEBKGD) which allow the agent **1002** or **1010** to see requests by Windows for a window to perform a paint operation within a region. Each time the agent **1002** or **1010** identifies one of these messages, the corresponding region is added to the clipping region for the associated window. The agent **1002** or **1010** uses knowledge of which windows receive which paint requests to maintain a record of which regions of the screen "belong" to each application window. Each time the agent **1002** or **1010** intercepts a paint request for a different window covering (all or part of) an existing clipping region for another window, that part is removed from that window's clipping region. The agent **1002** or **1010** can also directly retrieve the clipping region using Windows API functions such as GetRandomRgn() which allows the agent **1002** or **1010** to directly interrogate a window for clipping regions. In some embodiments, the agents **1002** and **1010** communicate as described above to exchange information required by the second agent **1010** to modify the local display **1012** or local windows **1014** or local windows corresponding to the plurality of windows **1006a-n**, as described below in connection with FIG. 11B.

The first agent transmits, to a second agent on the second machine, at least one entry in the z-order list associated with a window in the plurality of windows in the computing environment (step **1106**). In some embodiments, the first agent **1002** transmits to the second agent **1010** the entire z-order list. In other embodiments, the first agent **1002** transmits to the second agent **1010** a partial z-order list. In one embodiment, the first agent **1002** transmits the at least one entry in the z-order list to the second agent **1010** via a virtual channel coupled to the computing environment **1004**. In another embodiment, the first agent **1002** transmits, to the second agent **1010**, via a virtual channel conveying window attribute data associated with the proxy window **1008**, messages directing the modification of a corresponding local window **1014**, which displays, in accordance with the window

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attribute data conveyed by the virtual channel, graphical output data generated by a resource **1020** executing on the second client **102b**.

In one embodiment, the second client **102b** displays a local version of each of the plurality of windows **1006a-n**. In another embodiment, the second agent **1010** directs a window management component on the second client **102b** to assign each of the locally-displayed windows **1006a-n** a z-order entry in a z-order list of windows displayed on the second client **102b**. Each of the assigned z-order entries for each of the locally-displayed windows **1006a-n** result in the display of the locally-displays windows **1006a-n** above a local window associated with a local application on the second client **102b** other than the local display of a local application displayed in local window **1014**. In this embodiment, the local window is kept below the local display **1012** of the computing environment **1004** in the client-side Z-order—that is, it is kept below each of the windows in the plurality of windows **1006a-n** and below the local window **1014**, which is integrated with the plurality of windows **1006a-n**. In still another embodiment, the plurality of windows **1006a-n** and the local window **1014** are displayed on the second client **102b** according to the z-order list maintained on the first client **102a**.

The first agent receives an identification of a change to window attribute data associated with the window on the second machine (step **1108**). In one embodiment, the first agent **1002** receives the identification of the change via a virtual channel. In another embodiment, the first agent **1002** receives a message that a user minimized the local window **1014**. In still another embodiment, the first agent **1002** receives a message that a user restored a minimized local window **1014**. In still even another embodiment, the first agent **1002** receives a message that a user changed a size or position of the local window **1014**. In yet another embodiment, the first agent **1002** receives a message that a user maximized a local window **1014**.

The first agent modifies the computing environment, responsive to the identification of the change (step **1110**). In some embodiments, the first agent **1002** directs a window management component of an operating system executing on the first client **102a** to modify a window displayed in the computing environment. In other embodiments, the first agent **1002** sends a message to the second agent **1010** to restore the local window **1014**. In one of these embodiments, the second agent **1010** sends a message to the resource **1020** to restore the minimized local window **1014**. In another of these embodiments, the first agent **1002** sends a message to a window management component of an operating system executing on the first client **102a** to restore the proxy window **1008**. In still other embodiments, the first agent **1002** sends a message to the second agent **1010** to terminate the execution of a local resource **1020** when the first agent **1002** terminates the generation and display of the computing environment **1004**. In some embodiments, the first agent **1002** sends a message to the second agent **1010** to terminate an operating system executing on the second client **102b**. In one of these embodiments, the first agent **1002** sends a message to the second agent **1010** to shut down the second client **102b**.

In one embodiment, when a window **1006a** associated with a remote resource **1015** is selected by a user and the local window **1014** loses focus, the second agent **1010** transmits a message to the first agent **1002** instructing the first agent **1002** to direct a window management component to remove focus from the proxy window **1008** and to focus on a window **1006a** in the plurality of windows **1006a-n**. In another embodiment, when a window **1006a** associated with a remote resource **1015** is selected by a user and the local window **1014** loses

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focus, the second agent **1010** allows the resource **1020** to paint inside its window, resulting in a completely transparent view of local and remote resources.

Referring now to FIG. 11B, a flow diagram depicts one embodiment of the steps taken in a method for displaying, on the local machine, a desktop environment that is generated by the remote machine, the computing environment providing integrated access to both resources provided by the local machine and to resources provided by the remote machine. In brief overview, the method includes the step of displaying, by an agent executing on a local machine, a computing environment generated by a remote machine and providing access to i) a remote resource available to a user of the local machine, and to ii) a local resource available to the user of the local machine (step **1120**). The agent receives at least one entry in a z-order list including a z-order entry of at least one window in the computing environment and including the z-order entry of a proxy window corresponding to a local window on the local machine displaying output data generated by the local resource (step **1122**). The agent modifies window attribute data for the displayed computing environment, responsive to the received z-order entry (step **1124**). The agent executing on the local machine transmits, to an agent on the remote machine, an identification of a change to a z-order entry of a local window on the local machine displaying output data generated by the local resource (step **1126**). The agent on the remote machine modifies a z-order entry for a proxy window representing the local window in a z-order list on the remote machine, responsive to the identification of the change, the proxy window having a z-order entry in a z-order list associated with the plurality of windows in the computing environment (step **1128**).

An agent executing on a local machine displays a computing environment generated by a remote machine and providing access to i) a remote resource available to a user of the local machine, and to ii) a local resource available to the user of the local machine (step **1120**). In one embodiment, the agent **1010** receives graphical data and window attribute data from the agent **1002** and displays the graphical data in a window formed according to the window attribute data. In another embodiment, the agent **1010** receives graphical data and corresponding window attribute data for a plurality of windows forming a computing environment and displays the graphical data in a plurality of windows formed according to the window attribute data. In other embodiments, the first agent **1002** and the second agent **1010** exchange window attribute data. In one of these embodiments, the first agent **1002** and the second agent **1010** also exchange graphical data. In another of these embodiments, a third agent executing on the first client **102a** and the second agent **1010** exchange graphical data. In still another of these embodiments, a third agent executing on the first client **102a** and a fourth agent executing on the second client **102b** exchange graphical data. In yet another of these embodiments, the first agent **1002** on the first client **102a** and a fourth agent executing on the second client **102b** exchange graphical data.

The agent receives at least one entry in a z-order list including a z-order entry of at least one window in the computing environment and including the z-order entry of a proxy window corresponding to a local window on the local machine displaying output data generated by the local resource (step **1122**). In one embodiment, the agent **1010** displays a local window **1014** displaying output data, generated by an execution of the resource **1020**, and a plurality of windows **1006a-n** formed in accordance with received window attribute data, in accordance with the at least one entry in the z-order. In another embodiment, the agent **1010** monitors the local display

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play of the plurality of windows **1006a-n** and of the local window **1014**. In another embodiment, the agent **1010**, in communication with a window management component of an operating system executing on the second client **102b**, manages the local display of the plurality of windows **1006a-n** and of the local window.

The agent modifies window attribute data for the displayed computing environment, responsive to the received z-order entry (step **1124**). In some embodiments, the agent modifies a z-order entry for a local version of a window **1006a** in the plurality of windows **1006a-n**. In other embodiments, the agent modifies window attribute data for a local version of a window **1006a** in the plurality of windows **1006a-n**. In one of these embodiments, the agent resizes the local version of the window **1006a** in the plurality of windows **1006a-n**. In one of these embodiments, the agent repositions the local version of the window **1006a** in the plurality of windows **1006a-n**. For example, the agent may modify window attribute data of the local window **1014** responsive to the received z-order entry sent as a result of a window management component implementing a window cascade on the server.

In some embodiments, as described above in connection with FIG. 11A (step **1106**), rather than receiving a z-order entry, the second agent **1010** receives an identification of a clipping region in the computing environment corresponding to a region on the local display **1012** associated with a local resource **1020**. In one of these embodiments, the second agent **1010** receives the identification from the first agent **1002**. In another of these embodiments, described in additional detail above, the second agent **1010** identifies the region responsive to information received from the first agent **1002**. In still another of these embodiments, as described in additional detail above, the second agent **1010** identifies the region responsive to identifying a color key in a communication from the first agent **1002**.

The agent executing on the local machine transmits, to an agent on the remote machine, an identification of a change to a z-order entry of a local window on the local machine displaying output data generated by the local resource (step **1126**). In one embodiment, when a user of the second client **102b** makes a change to a local window **1014**, for example, by minimizing, maximizing, or resizing the window, the agent **1010** transmits a message to the agent **1002** to make a corresponding change to the proxy window **1008** and to its z-order entry in the z-order list ordering the plurality of windows **1006a-n** and the proxy window **1008**.

The agent on the remote machine modifies a z-order entry for a proxy window representing the local window in a z-order list on the remote machine, responsive to the identification of the change, the proxy window having a z-order entry in a z-order list associated with the plurality of windows in the computing environment (step **1128**). In one embodiment, the agent **1010** assigns the local window **1014** a z-order entry synchronized with the z-order entry of the proxy window **1008**, which has a z-order entry in a z-order list including z-order entries for a plurality of windows **1006a-n**. In another embodiment, generating a z-order list including entries both for windows generated by a resource executing on a server **106** and for windows generated by a resource executing on a client **102** allows for integrated and overlapping displays of local and remote windows.

Referring now to FIG. 12A, a block diagram depicts one embodiment of a system for generating a computing environment on the remote machine for display on the local machine, the computing environment providing integrated access to both resources provided by the local machine and to resources provided by a second remote machine. In brief overview, the

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system includes a first client **102a**, a first agent **1002**, a second client **102b**, a second agent **1010**, and a remote machine **106'**. The first agent **1002** receives an identification of a remote resource **1210** available to a user of the second client **102b** and provided by the remote machine **106'**. The first agent **1002**, executing on the first client **102a**, generates a computing environment **1004**, which includes a plurality of windows **1006a-206n** and provides access to i) a resource **1210** available to a user of the second client **102b** and provided by the remote machine **106'**, and ii) a resource **1020** provided by the second client **102b** that is available to the user of the second client **102b**. The first agent **1002** receives a request for execution of the remote resource **1210** provided by the remote machine **106'**. The first agent **1002** directs the second agent **1010** on the second client **102b** to request execution of the remote resource **1210** provided by the remote machine **106'**. The second agent **1010** transmits to the first agent **1002** an identification of a change to a z-order entry of a local window **1014** on the second client **102b**, the local window **1014** displaying output data generated by the remote resource **1210** provided by the remote machine **106'**. The first agent **1002** modifies a z-order entry for a proxy window **1008** representing the local window **1014** in a z-order list on the first client **102a**, responsive to the identification of the change, the proxy window **1008** having a z-order entry in a z-order list associated with the plurality of windows **1006** in the computing environment **1004**.

The second agent **1010** provides access to the computing environment **1004**. In some embodiments, establishment of a seamless pass-through presentation layer protocol connection between the computing environment **1004** to the remote machine **106'** is requested. In one of these embodiments, a second client agent **1010'** is executed on the second client **102b** to instead establish the connection between the second client **102b** and the remote machine **106'**. In another of these embodiments, the second client agent **1010'** looks like a client-side application that is accordingly integrated into the remote desktop by the second agent **1010** and the first agent **1002** using the methods described above in connection with FIGS. **10A**, **10B**, **11A**, and **11B**. In one embodiment, the second client agent **1010'** is an RDP client. In another embodiment, the second client agent **1010'** is an ICA client.

Referring now to FIG. **12B**, a screen shot depicts one embodiment of a system for generating a computing environment on the remote machine for display on the local machine, the computing environment providing integrated access to both resources provided by the local machine and to resources provided by a second remote machine. As depicted in FIG. **12B**, two presentation layer protocol sessions are executed on the second client **102b**. Session **1220**, with the bold boundary, is an ICA session providing access to a desktop environment **1004**. Session **1230**, with the dashed boundary, is an ICA session providing access to a resource (in FIG. **12B**, the resource is a word processing program, MICROSOFT WORD). The WORD application window, which is local window **1014**, has been merged with the presentation of the desktop session, which is represented by the computing environment **1004**. If the first client **102a** had established the session, the first client **102a** would have received the output data and would have then forwarded the output data to the second client **102b** for display. Instead, in this embodiment, the second client **102b** established the presentation layer protocol session required to access WORD, instead of the first client **102a** establishing a presentation layer protocol session, and the second client **102b** receives the output data directly from the remote machine **106**.

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Referring now to FIG. **13**, a flow diagram depicts one embodiment of the steps taken in a method for generating a computing environment on the remote machine for display on the local machine, the computing environment providing integrated access to both resources provided by the local machine and to resources provided by a second remote machine, includes the step of receiving, by a first agent executing on a first machine, an identification of a remote resource available to a user of a second machine, the remote resource provided by a third machine (step **1302**). The first agent monitors a computing environment on the first machine, the computing environment comprising a plurality of windows and providing access to i) the remote resource provided by the third machine and ii) a resource provided by the second machine that is available to the user of the second machine (step **1304**). The first agent receives a request for execution of the remote resource provided by the third machine (step **1306**). The first agent directs a second agent on the second machine to request execution of the remote resource provided by the third machine (step **1308**). The second agent transmits, to the first agent, an identification of a change to a z-order entry of a local window on the second machine displaying output data generated by the remote resource provided by the third machine (step **1310**). The first agent modifies a z-order entry for a proxy window representing the local window in a z-order list on the first machine, responsive to the identification of the change, the proxy window having a z-order entry in a z-order list associated with the plurality of windows in the computing environment (step **1312**).

Referring now to FIG. **13**, and in greater detail, a first agent executing on a first machine receives an identification of a remote resource available to a user of a second machine, the remote resource provided by a third machine (step **1302**). In one embodiment, the first agent **1002** receives the identification from the remote machine **106'**. In another embodiment, the first agent **1002** receives the identification from the second client **102b**. In still another embodiment, the first agent **1002** receives the identification from an agent on one of the remote machine **106'** and the second client **102b**. In yet another embodiment, the first agent **1002** receives the identification from a fourth machine **106''**. In one embodiment, a resource **1210** comprises a program, an application, a document, a file, a plurality of applications, a plurality of files, an executable program file, a desktop environment, a computing environment, or other resource made available to a user of the second client **102b**. The resource **1210** may be delivered to the remote machine **106** via a plurality of access methods including, but not limited to, conventional installation directly on the remote machine **106**, delivery to the remote machine **106** via a method for application streaming, or execution from a removable storage device connected to the remote machine **106**, such as a USB device.

The first agent monitors a computing environment on the first machine, the computing environment comprising a plurality of windows and providing access to i) the remote resource provided by the third machine and ii) a resource provided by the second machine that is available to the user of the second machine (step **1304**). In some embodiments, the first agent monitors the computing environment **1004** as described above in connection with FIGS. **10A**, **10B**, **11A**, and **11B**.

The first agent receives a request for execution of the remote resource provided by the third machine (step **1306**). In one embodiment, the first agent **1002** receives the request via a communications channel, such as an ICA channel, between the first agent **1002** and the second agent **1010**. In another

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embodiment, the first agent **1002** receives the request when a user of the second client **102b** selects a graphical representation of the remote resource **1210** depicted in the local display **1012** of the computing environment **1004**. For example, the first agent **1002** may generate a graphical representation of the remote resource **1210**, such as an icon, and incorporate the icon into the computing environment **1004** upon receiving the identification of the remote resource **1210** from the remote machine **106'**. In still another embodiment, the first agent **1002** receives a request for execution of the remote resource **1210** when a resource executing on one of the first client **102a** and the second client **102b** attempts to access a resource, such as a file, that requires the execution of the remote resource **1210**.

The first agent directs a second agent on the second machine to request execution of the remote resource provided by the third machine (step **1308**). In one embodiment, the first agent **1002** directs the second agent **1010** to execute another agent **1010'** on the second client **102b** and to instruct the second agent **1010'** to request execution of the remote resource **1210** provided by the remote machine **106'**. In another embodiment, the second agent **1010'** is a presentation layer protocol client, such as an ICA or RDP client. In still another embodiment, the second agent **1010'** establishes a connection to the remote machine **106'** and requests execution of the remote resource **1210**. In yet another embodiment, the second agent **1010'** receives output data generated by the execution of the remote resource **1210** and displays the output data in the local window **1014**. In some embodiments, the second agent **1010** directs the first agent **1002** to request execution of the remote resource **1210** on server **106** upon making a determination the requested resource is unavailable or not executable from the second client **102b**.

The second agent transmits, to the first agent, an identification of a change to a z-order entry of a local window on the second machine displaying output data generated by the remote resource provided by the third machine (step **1310**). In one embodiment the second agent **1010** transmits the identification of the change to the z-order entry of the local window **1014** to the first agent **1002**. In another embodiment the second agent **1010** transmits the identification of the change to the z-order entry of the local window **1014** to the first agent **1002** as described above in connection with FIGS. **10A**, **10B**, **11A**, and **11B**.

The first agent modifies a z-order entry for a proxy window representing the local window in a z-order list on the first machine, responsive to the identification of the change, the proxy window having a z-order entry in a z-order list associated with the plurality of windows in the computing environment (step **1312**). In some embodiments, the first agent **1002** modifies a z-order entry for a proxy window **1008** as described above in connection with FIGS. **10A**, **10B**, **11A**, and **11B**.

In some embodiments, methods and systems described herein provide functionality for addressing limitations on displaying output data on mobile devices, including limitations resulting from the relatively small display form factor and the limited computing capacity. In one of these embodiments, methods and systems are provided for turning the mobile device into an application delivery channel. In another of these embodiments, no changes are required of existing desktop applications to implement these methods and systems, and a wide variety of applications can be accessed on such an application-delivery enabled mobile device.

Referring now to FIG. **14A**, a block diagram depicts one embodiment of a system for executing on a mobile computing device a virtual input device for interacting with a resource,

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wherein output data for the resource is displayed on an external display device. In brief overview, the system includes a mobile computing device **102**, a native display **201** on the mobile computing device **102**, an external display device **202**, and a virtual input device **1402**. The mobile computing device **102** executes a first resource **1404**. The external display device **202** displays output data generated by the execution of the first resource **1404**. The mobile computing device **102** executes a second resource **1406**. The second resource **1406** generates a virtual input device **1402**. The virtual input device **1402** leverages one or more capabilities of the mobile computing device **102**. The virtual input device **1402** allows interaction by a user of the mobile computing device **102** with the display of output data generated by the execution of the first resource **1404**.

Referring now to FIG. **14A**, and in greater detail, the system includes a mobile computing device **102**. In one embodiment, the system is a mobile device **102** as described above in connection with FIGS. **1-13**. In another embodiment, the system includes a native display **201** on the mobile computing device **102**, an external display device **202**, and a virtual input device **1402**. The mobile computing device **102** executes a first resource **1404**.

The external display device **202** displays output data generated by the execution of the first resource **1404**. In one embodiment, the external display device **202** is a monitor. In another embodiment, the external display device **202** is a projector. In still another embodiment, the mobile computing device **102** is connected or attached to an external display device **202**, such as a projector that transmits output data to an external display surface. In various embodiments, the external display device **202** may be integrated into the mobile computing device **102**. For example, the mobile computing device **102** may include a pico projector, which directs a display of output data generated by a resource executing on the mobile computing device **102** to an external display surface such as a projection screen, wall, or other display surface. In some embodiments, the mobile computing device **102** may include a projection module based on a microelectromechanical system (MEMS), such as, for example and without limitation, a PicoP Display Engine manufactured by Microvision, Inc., of Redmond, Wash.

The mobile computing device **102** executes a second resource **1406**, which may be installed on the mobile computing device **102** or delivered to the mobile computing device **102** from a server **106**. The second resource **1406** generates a virtual input device **1402** for interaction by a user of the mobile computing device with the display of output data generated by the execution of the first resource. In various embodiments, the mobile computing device **102** may execute the second resource **1406** according to the input needs of the first resource **1404**, the input capabilities of the mobile computing device **102**, or both. In one embodiment, a virtual input device **1402** includes a graphical representation of a keyboard. In another embodiment, a virtual input device **1402** includes a virtual track pad. In still another embodiment, a virtual input device **1402** includes a virtual pointing device, such as a cursor which may be manipulated by interacting with the virtual input device **1402**.

The virtual input device **1402** may be displayed on the native display **201** on the mobile computing device **102**. The virtual input device **1402** allows interaction by a user of the mobile computing device **102** with the display of output data generated by the execution of the first resource **1404**. In some embodiments, the native display **201** on the mobile computing device **102** includes a touch-screen. In one of these embodiments, a touch-screen sensor includes a touch-respon-

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sive surface that detects touch input from a user of the mobile computing device **102**. In another of these embodiments, the virtual input device **140** is displayed on the touch-responsive surface. In still another of these embodiments, the touch-screen sensor redirects an identification of a location of the touch input on the touch-responsive surface to an operating system on the mobile computing device **102**. In another of these embodiments, the operating system redirects the identification of the location of the touch input to the second resource **1406** for processing. In still another of these embodiments, the second resource **1406** correlates the location of the touch input with a displayed user interaction element. In yet another of these embodiments, the second resource **1406** transmits an identification of a user interaction with the displayed user interaction element to the first resource **1404**.

In one embodiment, the virtual input device **1402** includes both a virtual keyboard and a virtual pointing device and interactions with these virtual components are redirected to the mobile device capabilities or to secondary external devices. For example, in another embodiments, mobile devices that have full QWERTY keyboards and cursor positioning buttons or joystick keys can have input received by the virtual keyboard and mouse redirected to those capabilities. In still another embodiment, mobile devices with touch screens can be repurposed as a “soft keyboard” and “soft mouse” and the input received by the virtual keyboard and mouse can be redirected directly to an executing resource. In still even another embodiment, input data received by a mobile device with an externally connected keyboard or mouse can be redirected to the virtual keyboard and mouse.

In some embodiments, a first resource **1404** may also accept input from other devices, such as camera, microphone, point-of-sale (POS) device, etc. In one of these embodiments, a virtual input device **1402** may provide a virtualized version of any such devices and can redirect data communication for these devices. For instance, and in another of these embodiments, if a mobile computing device **102** has a built-in camera, an application displayed on an external display device **202** and accepting input from a camera could be directed to use the mobile device camera. In still another of these embodiments, and by way of example, an application that has audio output could be directed, for example, to the mobile device’s speaker or headphone jack.

Referring now to FIG. **14B**, a screen shot depicts an embodiment of a mobile computing device **102** displaying a virtual input device **1402** on the native display **201**, wherein the virtual input device **1402** permits the user to interact with the output data associated with a resource **1406**, such as a word processing application. In this embodiment, the resource **1406** may be executing on the mobile computing device **102**. When the mobile computing device **102** is connected to the external display device **202**, the window management service **206** may detect the connection and display output data associated with the resource **1406** on the external display device **202** instead of the native display **201** of the mobile computing device **102**. In this embodiment, the external display device **202** is a projector that displays the output data on a surface, such as a wall.

In response to output data being transferred to the external display device **202**, the mobile computing device **102** may execute a resource that generates a virtual input device **1402**. The mobile computing device **102** may evaluate the resource **1406** to determine its input needs. In some embodiments, the mobile computing device **102** may determine that a resource accepts alphanumeric input, audio input, video input, or any other type of input or combinations thereof. In this embodiment, the resource **1402** is a word processing application that

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needs at least alphanumeric input. In response, the mobile computing device **102** executes a resource to generate a virtual or “soft” keyboard for a virtual input device **1402**. The virtual keyboard may be displayed on the native display **201**, such as a touch-screen. The touch-screen may detect user interactions and redirect information associated with the user interactions to the virtual input device **1402**. The virtual input device **1402** may communicate the resources to the resource **1402**.

Referring now to FIG. **14C**, a screen shot depicts an embodiment of a mobile computing device displaying a virtual input device **1402** for interaction by a user with a display of output data associated with a resource. In this embodiment, the mobile computing device **102** executes a resource to generate at least a virtual trackpad. The virtual trackpad may be displayed on the native display **201**, such as a touch-screen, of the mobile computing device **102**. When the touch-screen detects a user interaction, the touch-screen may redirect information associated with the user interaction to the resource generating the virtual input device **1402**. The virtual input device **1402** may process the information and determine a user command. The virtual input device **1402** may communicate the user command to the resource being displayed on an external display device (not shown), and the resource being displayed may output data corresponding to the user command.

The embodiment in FIG. **14C** also depicts a virtual input device **1402** that repurposes a keyboard on the mobile computing device **102** for the resource being displayed on an external display device. In this embodiment, the mobile computing device **102** displays a keyboard generated by an application installed on the device. The touch-screen may detect a user interaction and transmit information associated with the user interaction to the keyboard application. The keyboard application may interpret the user interaction to determine a user command, such as entering or deleting alphanumeric characters. The keyboard application may communicate the user command to the virtual input device **1402**, which may transmit information about the user command to the resource whose output data is being displayed on an external display device. In various embodiments, one resource may generate a virtual trackpad and another resource may repurpose the keyboard on the mobile computing device **102**. In other embodiments, the same resource may generate a virtual input device **1402** that generates the virtual trackpad and repurposes the keyboard.

Referring now to FIG. **15**, a flow diagram depicts one embodiment of a method for displaying, on a screen of a mobile computing device, a virtual input device for interacting with a resource generating output data displayed on a display surface external to the mobile computing device. The method includes executing, by a mobile computing device, a first resource (**1502**). The method includes directing a display, on an external display device, of output data generated by the executing first resource (**1504**). The method includes executing, on the mobile computing device, a second resource generating a virtual input device (**1506**). The method includes displaying, on a screen of the mobile computing device, the virtual input device (**1508**). The method includes transmitting, by the second resource to the first resource, an indication of an interaction by a user of the mobile computing device with the virtual input device (**1510**). In some embodiments, the mobile device **102** is repurposed as a virtual input device that transmits user input to either a locally-executing application or, via presentation-layer protocols, to a remotely-executing application.

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Referring now to FIG. 15, and in greater detail, a mobile computing device 102 executes a first resource (1502). In one embodiment, the mobile computing device 102 executes an application generating output data for display to a user of the mobile computing device. In some embodiments, the first resource requests, from a remote computing device, execution of a remotely-located resource. In one of these embodiments, a first resource communicates with the remote computing device according to a presentation layer protocol, for example, by communicating via the ICA protocol, or the RDP protocol. In another of these embodiments, the first resource directs the display of remotely-generated output data on a display device associated with the mobile computing device. In other embodiments, the first resource is stored on the mobile computing device, executes locally, and directs the display of locally-generated output data on a display device associated with the mobile computing device.

A display, by an external display device, of output data generated by the executing first resource is directed (1504). In one embodiment, a window management service directs the display of output data to the external display device 124b. In one embodiment, an operating system executing on the mobile computing device 102 and in communication with the external display device 124b directs the display of output data to the external display device 124b. In another embodiment, the external display device projects the output data to an external display surface, such as a wall, screen, or other surface. In still another embodiment, the display of the output data occurs without modification to the output data generated by the execution of the first resource. In some embodiments, the output data is rendered on a secondary physical display, such as an embedded or external micro projector, heads-up display, laptop, HDTV, or other display. In one of these embodiments, displayed output from the first resource is shown via the secondary display and is, therefore, not limited to only the display capabilities of the mobile computing device display.

The mobile computing device executes a second resource generating a virtual input device (1506). In one embodiment, the second resource communicates with the first resource. In another embodiment, the second resource identifies a type of virtual input device to display; for example, the second resource may select a type of virtual input device to display based on a type of interaction supported by the first resource.

The virtual input device is displayed on a screen of the mobile computing device (1508). In one embodiment, the virtual input device is displayed in conjunction with an existing virtual input device; for example, the mobile computing device may display a virtual (or “soft”) keyboard and the second resource may generate a second virtual input device, such as a virtual trackpad displayed in conjunction with the virtual keyboard. In another embodiment, the second resource may generate a customized virtual input device displayed on the mobile computing device in place of the display of output data generated by the first resource. In still another embodiment, the display of the output data generated by the first resource is separated from the display of the virtual input device, instead of combined into a singled display surface, such as either an internal or an external display device.

The second resource transmits, to the first resource, an indication of an interaction by a user of the mobile computing device with the virtual input device (1510). In some embodiments, the second resource communicates with the first resource, allowing a user to interact with the first resource via the virtual input device generated by the second resource and displayed on a separate display device than the first resource.

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In one embodiment, the first resource is a client application executing on the mobile computing device 102 and communicating with a remote computing device 106 according to a presentation layer protocol. In another embodiment, the first resource requests execution of a remote resource by the remote computing device. In still another embodiment, the first resource receives, from the remote computing device, output data generated by an execution of the remote resource on the remote computing device. In still even another embodiment, the first resource transmits, to the remote computing device, execution of a remote resource, and receives, from a second remote computing device, output data generated by an execution of the remote resource on the second remote computing device. In yet another embodiment, the mobile computing device directs a display of the remotely-generated output data on the external display device.

In some embodiments, the methods and systems described herein provide functionality for smart translation of user interaction with endpoint devices. In one of these embodiments, methods and systems are provided for translating a user interaction with an endpoint device into a command for processing by a remotely-executing resource. In another of these embodiments, for example, a resource may execute on a first computing device and generate output data that is displayed on a second computing device, which may be referred to as an endpoint device; a user interaction with the endpoint device may be translated into a command that is transmitted to the resource on the first computing device for processing.

In some embodiments, a resource executing on a first computing device provides a user interface allowing a user to interact with output data generated by a resource. In one of these embodiments, for example, output data may include one or more graphical user interface elements, such as a cursor or a scroll bar, displayed with data, such as the text in a word processing application or an image in an image viewing or editing software, and the graphical user interface elements provide a mechanism by which a user of the resource may interact with data generated by the resource. In another of these embodiments, the type of user interface varies based upon the computing environment from which the user views the output data. As described above, a first type of user interface may be provided when a user accesses output data from a mobile computing device and a second type of user interface may be provided when a user accesses output data from a different type of computing device, such as a laptop, or when the user has access to a different type of display device.

In some embodiments, methods for interacting with a user interface are different across different user interfaces—for example, users may access a pointing device (such as a mouse) to manipulate an image of a cursor on a screen in order to interact with a graphical user interface element, or users may interact with a touch screen on a display device and use their fingers to tap on or drag graphical user interface elements from one portion of the display to another. In other embodiments, a method for interacting with a first type of user interface (for example, connecting a mouse to a computing device and using the mouse to control a cursor shown on a display device to interact with the first type of user interface) does not work when applied to a second type of user interface (for example, if a second type of user interface accepts as input a user touch to a screen, the second type of user interface may not provide functionality for displaying a cursor or for accepting input from a pointing device); even if the method does work, it may be a suboptimal method for interacting with the second type of user interface or it may only provide limited functionality for interacting with the second type of

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user interface. In one of these embodiments, a first type of user interface may be preferable for use on a first type of computing device—for example, a user interface that supports a user entering commands by touching a screen may be better suited for use on a computing device that includes a touch screen than on one that does not. In still other embodiments, a remotely-executing application generates and displays a first type of user interface intended for access via a first type of computing device but which is displayed to a user accessing the user interface from a second type of computing device. For example, a user may access a first type of user interface that was designed for access from a computing device including a pointing device from a computing device that includes a touch screen but not a pointing device.

In some embodiments, the methods and systems described herein provide functionality for translating input of a first type into a second type. In one of these embodiments, input provided by a user via a first type of interface is translated into a command that a second type of interface can process. In another of these embodiments, and by way of example, a user may view data including a user interface displaying interface elements such as a scroll bar and accepting input commands from the user via a pointing device; however, the user may enter a command via a touch screen and the command is translated into a format that the user interface can process. In still another of these embodiments, and as another example, a user viewing a first section of data may have requested a display of a second section of data, for example by using a touch screen to scroll through the data; the command to scroll from the first section of data to the second may be translated into a command to select a graphical user interface element for scrolling down (such as an arrow in a scroll bar) and transmitted to the resource generating the data. In yet another of these embodiments, implementation of this functionality allows a user of a first type of computing device to interact with a display of a first type of user interface using a second type of user interface element optimized for use on the first type of computing device.

Referring now to FIG. 16, a flow diagram depicts one embodiment of a method for translating a user interaction with an input/output device of a first type into a command for processing by a user interface supporting interaction with an input/output device of a second type. In brief overview, the method includes providing an input/output device of a first type for interaction with a user interface of a first type (1602). The method includes identifying a user interaction with a user interface of a second type via the input/output device of the first type (1604). The method includes generating, responsive to the identified user interaction, a command formatted for processing by the user interface of the second type according to a protocol for interacting with an input/output device of a second type (1606). The method includes processing the command by the user interface of the second type (1608).

Referring now to FIG. 16, and in greater detail, an input/output device of a first type is provided for interaction with a user interface of a first type (1602). In one embodiment, the input/output device of the first type is a touch screen. In another embodiment, the user interface of the first type includes functionality for processing touch screen-based interactions with user interface elements displayed by the user interface of the first type. In still another embodiment, the input/output device of the first type is an input/output device such as a keyboard or pointing device. In still even another embodiment, the user interface of the first type includes a graphical element (such as a cursor) displayed to a user and with which the user interacts via the input/output device of the first type. In yet another embodiment, the user

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interface of the first type provides functionality for processing interactions with the graphical element received via input/output devices such as keyboards or pointing devices.

In some embodiments, a user interface of a second type is displayed to a user. In one of these embodiments, a user of a mobile computing device 102 views a user interface of the second type generated by a resource executing on the mobile computing device 102. In another of these embodiments, a user of a mobile computing device 102 views a user interface of the second type generated by a resource executing on a remote computing device 106. In still another of these embodiments, the user interface of the second type does not include functionality for processing user input generated by user interactions with the input/output device of the first type. In yet another of these embodiments, and by way of example, a user interface of the second type may be a windowing environment that displays widgets such as pull-down menus, scroll bars, and task bars and that includes functionality for processing user input generated by a user interaction with a pointing device or keyboard (e.g., a user clicking on a scroll bar with a mouse), but may not include functionality for processing user input generated by a user interaction with a touch screen.

A user interaction with a user interface of a second type via the input/output device of the first type is identified (1604). In one embodiment, an interaction management component identifies the user interaction. In another embodiment, the user interaction is transmitted to an interaction management component for processing. In an embodiment in which the input/output device of the first type is a touch screen, a user may touch the screen of a mobile computing device in an attempt to manipulate data displayed by the user interface of the second type, such as a windowing environment displaying a pull-down menu.

A command is generated responsive to the identified user interaction, the command formatted for processing by the user interface of the second type according to a protocol for interacting with an input/output device of a second type (1606). In one embodiment, an interaction management component accesses a mapping, table, or other data structure storing configuration data to generate the command. In another embodiment, the interaction management component analyzes the user interaction with input/output device of the first type to identify a request or command intended by the user interaction; for example, the interaction management component may determine that a user touching a section of a touch screen intending to request access to data or to generate a command to modify an existing display of data. In still another embodiment, the interaction management component generates a type of command that is typically a result of a user interaction with the user interface of the second type. In yet another embodiment, and by way of example, the interaction management component determines that a user has interacted with a touch screen in order to request a modification of an existing display of data and the interaction management component generates a command equivalent to a command that would have been generated if the user had accessed an input/output device such as a mouse to select a graphical user interface element.

The command is processed by the user interface of the second type (1608). In one embodiment, the interaction management component transmits the command to a resource generating the user interface of the second type. In another embodiment, the interaction management component transmits the command to a resource executing on the mobile computing device 102. In another embodiment, the interac-

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tion management component transmits the command to a resource executing on a second computing device 106.

The systems and methods described above may be provided as one or more computer-readable programs embodied on or in one or more articles of manufacture. The article of manufacture may be a floppy disk, a hard disk, a CD-ROM, a flash memory card, a PROM, a RAM, a ROM, or a magnetic tape. In general, the computer-readable programs may be implemented in any programming language, LISP, PERL, C, C++, PROLOG, or any byte code language such as JAVA. The software programs may be stored on or in one or more articles of manufacture as object code.

Having described certain embodiments of methods and systems for displaying and activating disconnected application sessions, it will now become apparent to one of skill in the art that other embodiments incorporating the concepts of the invention may be used. Therefore, the invention should not be limited to certain embodiments.

What is claimed is:

1. A method of repurposing a mobile computing device as a virtual input device for a first resource being displayed on an external display device comprising:

displaying, by a mobile computing device, on a display of the mobile computing device, output data for a first resource executing on the mobile computing device;

determining, by the mobile computing device, that an external display device has been connected to the mobile computing device;

displaying, by the mobile computing device, on the external display device output data for the first resource executing on the mobile device, responsive to the determination;

transmitting, by the mobile computing device to a server, data indicating input capabilities of the mobile computing device and input requirements of the first resource;

receiving, by the mobile computing device from the server, a second resource executable by the mobile computing device to repurpose the mobile computing device as a first virtual input device for the first resource, the second resource selected by the server responsive to an identification by the server of the input capabilities of the mobile computing device and input requirements of the first resource;

executing, by the mobile computing device, the second resource to repurpose the mobile computing device as the first virtual input device for the first resource executing on the mobile device; and

delivering, by the server to the mobile computing device, a third resource that generates a second virtual input device in conjunction with the first virtual input device of the second resource.

2. The method of claim 1, further comprising delivering, by the server to the mobile computing device, the second resource that generates a virtual keyboard, virtual track pad, virtual pointing device, virtual camera, virtual microphone, virtual point-of-sale device, virtual speaker, virtual headphone jack, or any combination thereof.

3. The method of claim 1, further comprising delivering, by the server to the mobile computing device, the second resource that allows user interaction with output data of the first resource.

4. The method of claim 1, further comprising delivering, by the server to the mobile computing device, the second resource that transmits an identification of a user interaction with at least one of the first virtual input device or the second virtual input device to the first resource.

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5. The method of claim 1, further comprising delivering, by the server to the mobile computing device, the second resource that generates at least one user interaction element.

6. The method of claim 1, further comprising delivering, by the server to the mobile computing device, the second resource that redirects user interactions with at least one of the first virtual input device or the second virtual input device to the input capabilities of the mobile computing device.

7. The method of claim 1, further comprising delivering, by the server to the mobile computing device, the second resource that correlates a location of a touch input with a displayed user interaction element.

8. The method of claim 1, further comprising delivering, by the server to the mobile computing device, the second resource for display in conjunction with the first resource on a single display surface.

9. The method of claim 1, further comprising delivering, by the server to the mobile computing device, the second resource that generates a third virtual input device for a second external device connected to the mobile computing device.

10. A system for repurposing a mobile computing device as a virtual input device for a first resource being displayed on an external display device comprising:

an external display device;

a mobile computing device;

a server;

a client agent executing on the mobile computing device to: display on a display of the mobile computing device, output data for a first resource executing on the mobile computing device,

determine that the external display device has been connected to the mobile computing device,

display on the external display device output data for a first resource executing on the mobile device, responsive to the determination; and

a server agent executing on the server to:

receive data indicating input capabilities of the mobile computing device and data indicating input requirements of the first resource;

identify, responsive to the input capabilities of the mobile computing device and input requirements of the first resource a second resource to repurpose the mobile computing device as a first virtual input device for the first resource;

transmit to the mobile computing device the second resource;

delivers a third resource that generates a second virtual input device in conjunction with the first virtual input device of the second resource; and

wherein the mobile computing device executes the second resource to repurpose the mobile computing device as the first virtual input device for the first resource executing on the mobile device.

11. The system of claim 10, wherein the second resource generates a virtual keyboard, virtual track pad, virtual pointing device, virtual camera, virtual microphone, virtual point-of-sale device, virtual speaker, virtual headphone jack, or any combination thereof.

12. The system of claim 10, wherein the second resource allows user interaction with output data of the first resource.

13. The system of claim 10, wherein the second resource transmits an identification of a user interaction with at least one of the first virtual input device or the second virtual input device to the first resource.

14. The system of claim 10, wherein the second resource generates at least one user interaction element.

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15. The system of claim 10, wherein the second resource redirects user interactions with at least one of the first virtual input device or the second virtual input device to the input capabilities of the mobile computing device.

16. The system of claim 10, wherein the second resource correlates a location of a touch input with a displayed user interaction element.

17. The system of claim 10, wherein the second resource is displayed in conjunction with the first resource on a single display surface.

18. The system of claim 10, wherein the second resource generates a third virtual input device for a second external device connected to the mobile computing device.

19. A method of repurposing a mobile computing device as a virtual input device for a first resource being displayed on an external display device comprising:

displaying, by a mobile computing device, on a display of the mobile computing device, output data for a first resource executing on the mobile computing device;

determining, by the mobile computing device, that an external display device has been connected to the mobile computing device;

displaying, by the mobile computing device, output data for the first resource executing on the mobile device, on the external display device, responsive to the determination;

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transmitting, by the mobile computing device to a server, data indicating input capabilities of the mobile computing device and input requirements of the first resource; receiving, by the mobile computing device from the server, a second resource executable by the mobile computing device to generate a first virtual input device displayed on the display of the mobile computing device for the first resource, the second resource selected by the server responsive to an identification by the server of the input capabilities of the mobile computing device and input requirements of the first resource;

executing, by the mobile computing device, the second resource to generate a first virtual input device displayed on the display of the mobile computing device, responsive to the determination;

delivering, by the server to the mobile computing device, a third resource that generates a second virtual input device in conjunction with the first virtual input device of the second resource; and

transmitting, by the second resource to the first resource, a user interaction with at least one of the first virtual input device or the second virtual input device.

20. The method of claim 1, further comprising selecting, by the mobile computing device, a type of virtual input to display using the second resource based on a type of interaction supported by the first resource.

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